HOLDEN COMMODORE
VT VX VY VZ
WORKSHOP/REPAIR MANUAL

Holden

Commodore

Sedan, Wagon and Utility

Series VT, VTII, VX, VXII, VY, VYII, VZ and VZII

1997 – 2006 (Wagon and Utility models to 2007)

All models with 3.6L and 3.8L V6 engines including supercharged models, 5.0L, 5.7L Generation III and 6.0L Generation IV V8 engines.

Introduction

The Holden Commodore is available in four door sedan, station wagon and utility body styles. Six cylinder VT to VY models are fitted with the 3.8L Ecotec engine. Six cylinder VZ models have the new 3.6L Alloytec engine. The 5.0L OHV V8 engine was fitted to Series I VT's. With the release of the Series II VT, the 5.7L Generation III engine was adopted and this was used until the release of VZ Series II, when the 6.0L Generation IV engine was released.

All years use conventional front-engine, rear wheel drive configurations. All models have multi-port fuel injection. A supercharger is available as an option on V6 models.

Power from the engine passes through one of four types of transmissions, a five-speed manual transmission, six-speed manual transmission, a four-speed electronic automatic or a five-speed electronic automatic transmission to the rear differential.

The individually-sprung rear wheels are driven by two driveaxles from the solid-mounted final-drive unit. The independent front suspension features MacPherson struts and power assisted rack and pinion steering.

Disc brakes are used on all four wheels and an Anti-lock Braking System (ABS) is available on some models.

Contents

Holden Commodore VT series

Holden Commodore VY series

About this manual

ITS PURPOSE

The purpose of this manual is to help you get the best value from your vehicle. It can do so in several ways. It can help you decide what work must be done, even if you choose to have it done by a dealer service department or a repair shop; it provides information and procedures for routine maintenance and servicing; and it offers diagnostic and repair procedures to follow when trouble occurs.

We hope you use the manual to tackle the work yourself. For many simpler jobs, doing it yourself may be quicker than arranging an appointment to get the vehicle into a shop and making the trips to leave it and pick it up. More importantly, a lot of money can be saved by avoiding the expense the shop must pass on to you to cover its labor and overhead costs. An added benefit is the sense of satisfaction and accomplishment that you feel after doing the job yourself.

USING THE MANUAL

The manual is divided into Chapters. Each Chapter is divided into numbered Sections, which are headed in bold type below a horizontal line. Each Section consists of consecutively numbered paragraphs.

At the beginning of each numbered Section you will be referred to any illustrations which apply to the procedures in that Section. The reference numbers used in illustration captions pinpoint the pertinent Section and the Step within that Section. That is, illustration 3.2 means the illustration refers to Section 3 and Step (or paragraph) 2 within that Section.

Procedures, once described in the text, are not normally repeated. When it's necessary to refer to another Chapter, the reference will be given as Chapter and Section number. Cross references given without use of the word "Chapter" apply to Sections and/or paragraphs in the same Chapter. For example, "see Section 8" means in the same Chapter.

References to the left or right side of the vehicle assume you are sitting in the driver's seat, facing forward.

Even though we have prepared this manual with extreme care, neither the publisher nor the author can accept responsibility for any errors in, or omissions from, the information given.

NOTE

*A **Note** provides information necessary to properly complete a procedure or information which will make the procedure easier to understand.*

CAUTION

*A **Caution** provides a special procedure or special steps which must be taken while completing the procedure where the Caution is found. Not heeding a Caution can result in damage to the assembly being worked on.*

WARNING

*A **Warning** provides a special procedure or special steps which must be taken while completing the procedure where the Warning is found. Not heeding a Warning can result in personal injury.*

Vehicle identification numbers

VEHICLE IDENTIFICATION NUMBER (VIN)

This very important identification number is on a metal plate which is riveted to the car at the lower left side of the windshield (see illustration). On VZ models, it is also stamped into the floor of the vehicle beneath the driver seat. It can be seen after sliding the driver seat rearward and then lifting the flap of carpet up between the front seat mounting bolts.

VIN MODEL AND ENGINE CODES

The VIN contains important information about the vehicle such as trim level, body style, engine type, year manufactured, production plant and safety features as well as an identification number unique to each body shell.

BODY OPTION AND IDENTIFICATION PLATE

This plate carries important information about when the vehicle was manufactured, paint colour and trim level as well as drivetrain and suspension options (see illustration).

SAFETY COMPLIANCE PLATE

This plate is located on the firewall in the engine compartment (see illustration). This plate carries important information about approval number, vehicle category code, make/model, gross vehicle mass, seating capacity, seat belt provisions, manufacture dates and the VIN number.

ENGINE NUMBER

The engine serial number is stamped on the left front of the block, just below the cylinder head on both the Ecotec V6 and 5.0L V8 engines. On the 3.6L Alloytec engine it is stamped on the LH rear of the cylinder block, near the starter motor. On the GEN III and GEN IV V8s, the engine number is stamped on the RHF of the cylinder block, just below the cylinder head.

TRANSMISSION NUMBER

The manual transmission serial number is located on a label on the front left side of the transmission. The automatic transmission serial number is located on the bottom of the case, next to the rear edge of the fluid pan (see illustration).

DIFFERENTIAL NUMBER AND RATIO

The differential serial number and gear ratio are located on a label on the right side of the housing (see illustration).

Read the VIN directly through the windshield glass

Safety compliance plate location (arrow)

The body option and identification plate is located behind the left headlight

The automatic transmission serial number is visible from below the vehicle

The identification tag and gear ratio tag is found on the left side of the differential housing

Recall information

Vehicle recalls are carried out by the manufacturer in the rare event of a possible safety-related defect. The vehicle's registered owner is contacted with details of the recall. Remedial work is carried out free of charge at a dealer service department.

If you are not the original owner of the vehicle and you wish to determine if a recall has been carried out, contact your local dealer and quote the vehicle identification number (VIN). The dealer will be able to inform you if there are any outstanding recalls on that particular vehicle.

Most vehicles have a form in the owner's manual that can be filled out by subsequent vehicle owners. If this form is submitted to the manufacturer, the owner will receive information about any future vehicle recall notifications.

The recall information below is current at the time of production.

To check for further recall campaigns, visit the Department of Transport and Regional Services (DOTARS) website, which is the governing body overseeing these issues, at http://dynamic.dotars.gov.au.

Recall date	Recall campaign number (DOTARS No)	Model(s) affected	Concern
17 December 2004	R05/001	VZ Commodore	Some LH rear doors may have defective spot welding.
17 December 2004	R05/002	VZ Commodore	Tyre beads may have been damaged when being fitted to the rim.
15 June 2005	R05/076	VZ Commodore	The clip holding the brake hose against the front strut may not secure the hose properly.
7 April 2006	R06/045	VY, VY2, V2, VZ 1/4/2003-2/12/2005	Possibility of passenger or driver side airbag in the seat discharging when vehicle is stationary and occupant is exiting vehicle.
9 November 2006	R06/147	VZ Commodore 1/5/2004-30/7/2004	Plenum chamber retaining clip for the fuel hose may damage the hose on some vehicles.
9 November 2006	R06/149	VZ Commodore	The diagnostic link in the wiring harness under the dash may not be secured with proper clearance. The drivers foot when using the brake may contact the harness.
6 May 2004	R04/060	VY Commodore 26/8/2002-2/9/2003	A power steering cooler hose may rupture during cornering
24 May 2004	R04/062	VY Commodore	Some driver's seats have been manufactured with incomplete riveting and welding between the seat track and the mounting foot on the front right hand side.
30 July 2001	R01/065	VT, VX Commodore	Low beam headlamp relay faulty.
2 November 2001	R01/094	VT, VX, VU Commodore	Due to a brittle condition of the metal the towbar tongue (gooseneck) may snap.

Buying parts

Spare parts are available from many-sources, which generally fall into one of two categories - authorised dealer parts departments and independent retail auto parts stores. Our advice concerning these parts is as follows:

Retail auto parts stores: Good auto parts stores will stock frequently needed components which wear out relatively fast, such as clutch components, exhaust systems, brake parts, tune-up parts, etc. These stores often supply new or reconditioned parts on an exchange basis, which can save a considerable amount of money. Discount auto parts stores are often very good places to buy materials and parts needed for general vehicle maintenance such as oil, grease, filters, spark plugs, belts, touch-up paint, bulbs, etc. They also usually sell tools and general accessories, have convenient hours, charge lower prices and can often be found not far from home.

Authorised dealer parts department: This is the best source for parts which are unique to the vehicle and not generally available elsewhere (such as major engine parts, transmission parts, trim pieces, etc.).

Warranty information: If the vehicle is still covered under warranty, be sure that any renewal parts purchased - regardless of the source - do not invalidate the warranty!

To be sure of obtaining the correct parts, have engine and chassis numbers available and, if possible, take the old parts along for positive identification.

Maintenance techniques, tools and working facilities

MAINTENANCE TECHNIQUES

There are a number of techniques involved in maintenance and repair that will be referred to throughout this manual. Application of these techniques will enable the home mechanic to be more efficient, better organised and capable of performing the various tasks properly, which will ensure that the repair job is thorough and complete.

Fasteners

Fasteners are nuts, bolts, studs and screws used to hold two or more parts together. There are a few things to keep in mind when working with fasteners. Almost all of them use a locking device of some type, either a lockwasher, locknut, locking tab or thread adhesive. All threaded fasteners should be clean and straight, with undamaged threads and undamaged corners on the hex head where the spanner fits. Develop the habit of all damaged nuts and bolts with new ones. Special locknuts with nylon or fibre inserts can only be used once. If they are removed, they lose their locking ability and must be renewed.

Rusted nuts and bolts should be treated with a penetrating fluid to ease removal and prevent breakage. Some mechanics use turpentine in a spout-type oil can, which works quite well. After applying the rust penetrant, let it work for a few minutes before trying to loosen the nut or bolt. Badly rusted fasteners may have to be chiselled or sawed off or removed with a special nut breaker, available at tool stores.

If a bolt or stud breaks off in an assembly, it can be drilled and removed with a special tool commonly available for this purpose. Most automotive machine shops can perform this task, as well as other repair procedures, such as the repair of threaded holes that have been stripped out.

Flat washers and lockwashers, when removed from an assembly, should always be refitted exactly as removed. Renew any damaged washers. Never use a lockwasher on any soft metal surface (such as aluminium), thin sheet metal or plastic.

Fastener sizes

For a number of reasons, automobile manufacturers are making wider and wider use of metric fasteners. Therefore, it is important to be able to tell the difference between standard (sometimes called US or SAE) and metric hardware, since they cannot be interchanged.

All bolts, whether standard or metric, are sized according to diameter, thread pitch and length. For example, a standard M12 - 1.75 x 25 metric bolt is 12 mm in diameter, has a thread pitch of 1.75 mm (the distance between threads) and is 25 mm long. The two bolts are nearly identical, and easily confused, but they are not interchangeable.

In addition to the differences in diameter, thread pitch and length, metric and standard bolts can also be distinguished by examining the bolt heads. To begin with, the distance across the flats on a standard bolt head is measured in inches, while the same dimension on a metric bolt is sized in millimetres (the same is true for nuts). As a result, a standard spanner should not be used on a metric bolt and a metric spanner should not be used on a standard bolt. Also, most standard bolts have slashes radiating out from the centre of the head to denote the grade or strength of the bolt, which is an indication of the amount of torque that can be applied to it. The greater the number of slashes, the greater the strength of the bolt. Grades 0 through 5 are commonly used on automobiles. Metric bolts have a property class (grade) number, rather than a slash, moulded into

their heads to indicate bolt strength. In this case, the higher the number, the stronger the bolt. Property class numbers 8.8, 9.8 and 10.9 are commonly used on automobiles.

Strength markings can also be used to distinguish standard hex nuts from metric hex nuts. Many standard nuts have dots stamped into one side, while metric nuts are marked with a number. The greater the number of dots, or the higher the number, the greater the strength of the nut.

Metric studs are also marked on their ends according to property class (grade). Larger studs are numbered (the same as metric bolts), while smaller studs carry a geometric code to denote grade.

It should be noted that many fasteners, especially Grades 0 through 2, have no distinguishing marks on them. When such is the case, the only way to determine whether it is standard or metric is to measure the thread pitch or compare it to a known fastener of the same size.

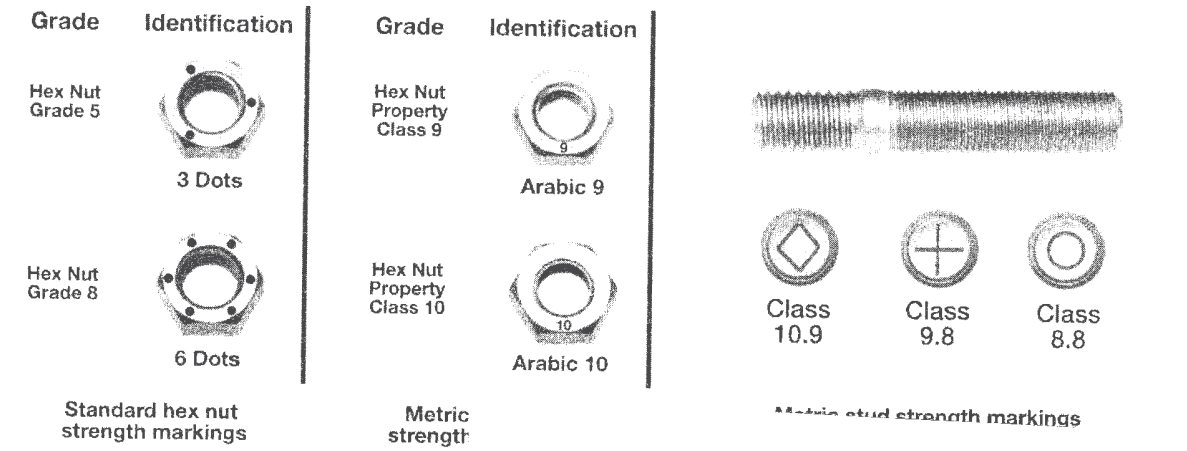
Standard fasteners are often referred to as SAE, as opposed to metric. However, it should be noted that SAE technically refers to a non-metric fine thread fastener only. Coarse thread non-metric fasteners are referred to as USS sizes.

Since fasteners of the same size (both standard and metric) may have different strength ratings, be sure to refit any bolts, studs or nuts removed from your vehicle in their original locations. Also, when renewing a fastener, make sure that the new one has a-strength rating equal to or greater than the-original.

Tightening sequences and procedures

Most threaded fasteners should be tightened to a specific torque value (torque is the twisting force applied to a threaded component such as a nut or bolt). Overtightening the fastener can weaken it and cause it to break, while undertightening can cause it to eventually come loose. Bolts, screws and studs, depending on the material they are made of and their thread diameters, have specific torque values, many of which are noted in the Specifications at the beginning of each Chapter. Be sure to follow the torque recommendations closely. For fasteners not assigned a specific torque, a general torque value chart is presented here as a guide. These torque values are for dry (unlubricated) fasteners threaded into steel or cast iron (not aluminium). As was previously mentioned, the size and grade of a fastener determine the amount of torque that can safely be applied to it. The figures

Bolt strength marking (standard/SAE/USS; bottom - metric)

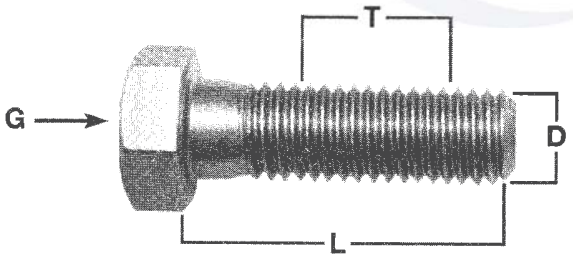


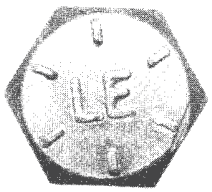
listed here are approximate for Grade 2 and Grade 3 fasteners. Higher grades can tolerate higher torque values.

Fasteners laid out in a pattern, such as cylinder head bolts, sump bolts, differential cover bolts, etc., must be loosened or tightened in sequence to avoid warping the component. This sequence will normally be shown in the appropriate Chapter. If a specific pattern is not given, the following procedures can be used to prevent warping.

Initially, the bolts or nuts should be assembled finger-tight only. Next, they should be tightened one full turn each, in a criss-cross or diagonal pattern. After each one has been tightened one full turn, return to the first one and tighten them all one-half turn,

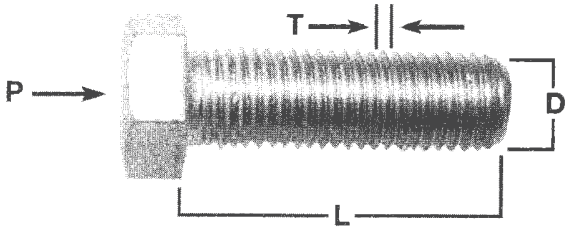
Metric thread sizes	Nm	Ft-lbs
M-6	9 to 12	6 to 9
M-8	19 to 28	14 to 21
M-10	38 to 54	28 to 40
M-12	68 to 96	50 to 71
M-14	109 to 154	80 to 140
Pipe thread sizes		
1/8	7 to 10	5 to 8
1/4	17 to 24	12 to 18
3/8	30 to 44	22 to 33
1/2	34 to 47	25 to 35
U.S. thread sizes		
1/4 - 20	9 to 12	6 to 9
5/16 - 18	17 to 24	12 to 18
5/16 - 24	19 to 27	14 to 20
3/8 - 16	30 to 43	22 to 32
3/8 - 24	37 to 51	27 to 38
7/16 - 14	55 to 74	40 to 55
7/16 - 20	55 to 81	40 to 60
1/2 - 13	75 to 108	55 to 80

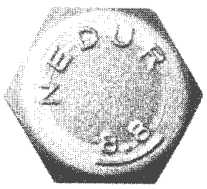




Standard (SAE and USS) bolt dimensions/grade marks

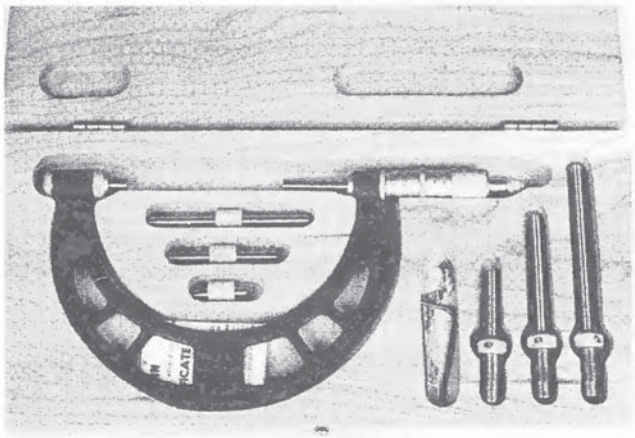
- *G* Grade marks (bolt strength)
- *L* Length (in inches)
- *T* Thread pitch (number of threads per inch)
- *D* Nominal diameter (in inches)



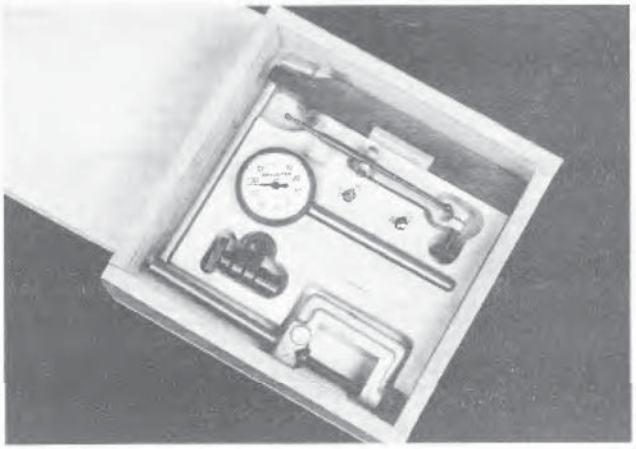


Metric bolt dimensions/grade marks

- *P* Property class (bolt strength)
- *L* Length (in millimeters)
- *T* Thread pitch (distance between threads in millimeters)
- *D* Diameter



Micrometer set



Dial indicator set

following the same pattern. Finally, tighten each of them one-quarter turn at a time until each fastener has been tightened to the proper torque. To loosen and remove the fasteners, the procedure would be reversed.

Component disassembly

Component disassembly should be done with care and purpose to help ensure that the parts go back together properly. Always keep track of the sequence in which parts are removed. Make note of special characteristics or marks on parts that can be refit more than one way, such as a grooved-thrust washer on a shaft. It is a good idea to lay the disassembled parts out on a clean surface in the order that they were removed. It may also be helpful to make sketches or take instant photos of components before removal.

When removing fasteners from a component, keep track of their locations. Sometimes threading a bolt back in a part, or putting the washers and nut back on a stud, can prevent mix-ups later. If nuts and bolts cannot be returned to their original locations, they should be kept in a compartmented box or a series of small boxes. A cupcake or muffin tin is ideal for this purpose, since each cavity can hold the bolts and nuts from a particular area (i.e. sump bolts, valve cover bolts,-engine mount bolts, etc.). A pan of this type is especially helpful when working on assemblies with very small parts, such as the carburettor, alternator, valve train or interior dash and trim pieces. The cavities can be marked with paint or tape to identify the contents.

Whenever wiring looms, harnesses or connectors are separated, it is a good idea to identify the two halves with numbered pieces of masking tape so they can be easily reconnected.

Gasket sealing surfaces

Throughout any vehicle, gaskets are used to seal the mating surfaces between two parts and keep lubricants, fluids, vacuum or pressure contained in an assembly.

Many times these gaskets are coated with a liquid or paste-type gasket sealing compound before assembly. Age, heat and pressure can sometimes cause the two parts to stick together so tightly that they are very difficult to separate. Often, the assembly can be loosened by striking it with a soft-face hammer near the mating surfaces. A regular hammer can be used if a block of wood is placed between the hammer and the part. Do not hammer on cast parts or parts that could be easily damaged. With any particularly stubborn part, always recheck to make sure that every fastener has been removed.

Avoid using a screwdriver or bar to prise apart an assembly, as they can easily mar the gasket sealing surfaces of the parts, which must remain smooth. If levering is absolutely necessary, use an old broom handle, but keep in mind that extra clean up will be necessary if the wood splinters.

After the parts are separated, the old gasket must be carefully scraped off and the gasket surfaces cleaned. Stubborn gasket material can be soaked with rust penetrant or treated with a special chemical to soften it so it can be easily scraped off.

Caution: *Never use gasket removal solutions or caustic chemicals on plastic or other composite components.*

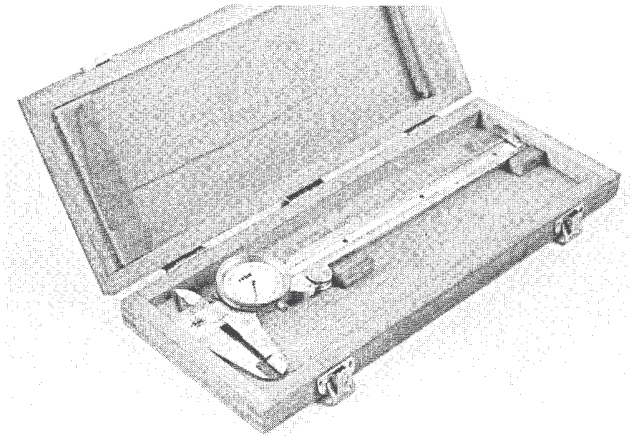
A scraper can be fashioned from a piece of copper tubing by flattening and sharpening one end. Copper is recommended because it is usually softer than the surfaces to be scraped, which reduces the chance of gouging the part. Some gaskets can be removed with a wire brush, but regardless of the method used, the mating surfaces must be left clean and smooth. If for some reason the gasket surface is gouged, then a gasket sealer thick enough to fill scratches will have to be used during reassembly of the components. For most applications, a non-drying (or semi-drying) gasket sealer should be used.

Hose removal tips

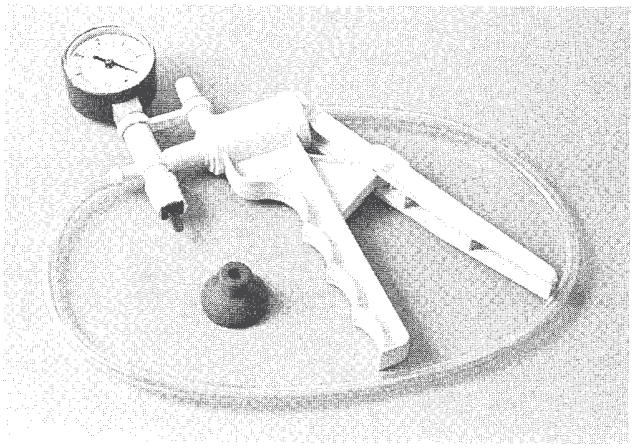
Warning: *If the vehicle is equipped with air conditioning, do not disconnect any of the A/C hoses without first having the system depressurised by a dealer service department or a service station.*

Hose removal precautions closely parallel gasket removal precautions. Avoid scratching or gouging the surface that the hose mates against or the connection may leak. This is especially true for radiator hoses. Because of various chemical reactions, the rubber in hoses can bond itself to the metal spigot that the hose fits over. To remove a hose, first loosen the hose clamps that secure it to the spigot. Then, with slip-joint pliers, grab the hose at the clamp and rotate it around the spigot. Work it back and forth until it is completely free, then pull it off. Silicone or other lubricants will ease removal if they can be applied between the hose and the outside of the spigot. Apply the same lubricant to the inside of the hose and the outside of the spigot to simplify refitting.

As a last resort (and if the hose is to be renewed anyway), the rubber can be slit with a knife and the hose peeled from the spigot. If this must be done, be careful that the metal connection is not damaged.

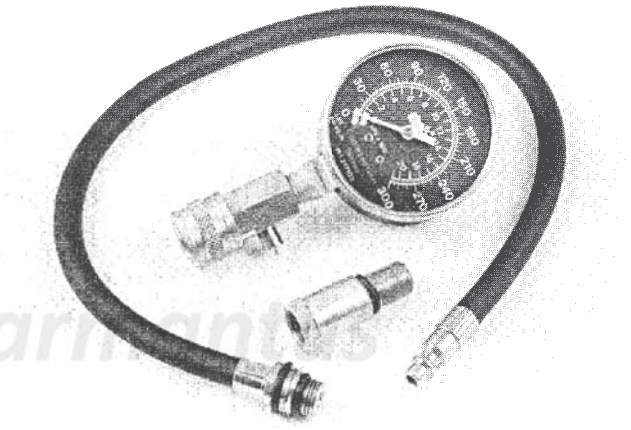


Dial caliper



Hand-operated vacuum pump

Timing light



Compression gauge with spark plug hole adapter

If a hose clamp is broken or damaged, do not reuse it. Wire-type clamps usually weaken with age, so it is a good idea to renew them with screw-type clamps whenever a hose is removed.

TOOLS

A selection of good tools is a basic requirement for anyone who plans to maintain and repair his or her own vehicle. For the owner who has few tools, the initial investment might seem high, but when compared to the spiralling costs of professional auto maintenance and repair, it is a wise one.

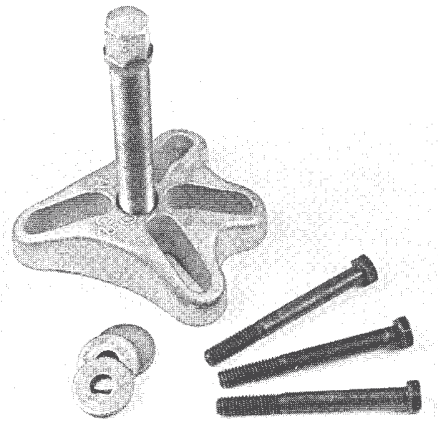
To help the owner decide which tools are needed to perform the tasks detailed in this manual, the following tool lists are offered: *Maintenance and minor repair, Repair/overhaul* and *Special*.

The newcomer to practical mechanics should start off with the *maintenance and minor repair* tool kit, which is adequate for the simpler jobs performed on a vehicle. Then, as confidence and experience grow, the owner can tackle more difficult tasks, buying additional tools as they are needed. Eventually the basic kit will be expanded into the repair and overhaul tool set. Over a period of time, the experienced do-it-yourselfer will assemble a tool set complete enough for most repair and overhaul procedures and will add tools from the special category when it is felt that the expense is justified by the frequency of use.

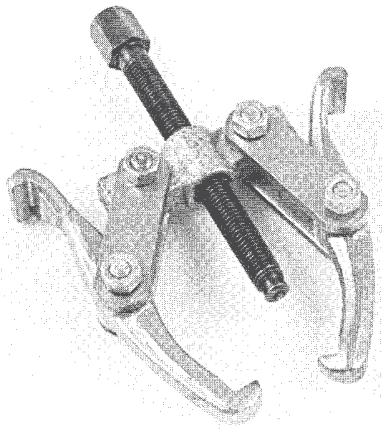
Maintenance and minor repair tool kit

The tools in this list should be considered the minimum required for performance of routine maintenance, servicing and minor repair work. We recommend the purchase of combination spanners (box-end and open-end combined in one spanner). While more expensive than open end spanners, they offer the advantages of both types of spanner.

Combination spanner set (6 mm to 19 mm)
Adjustable spanner
Spark plug spanner with rubber insert
Spark plug gap adjusting tool
Feeler gauge set
Brake bleeder spanner
Standard screwdriver
Phillips screwdriver
Combination pliers
Hacksaw and assortment of blades
Tyre pressure gauge
Grease gun
Oil can
Fine emery cloth
Wire brush

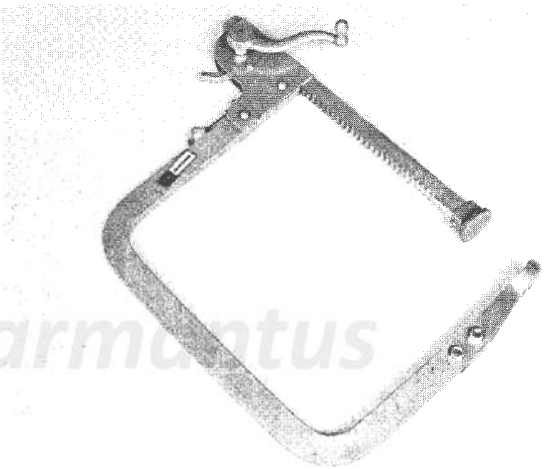


Damper/steering wheel puller



General purpose puller

Hydraulic lifter removal tool



Valve spring compressor

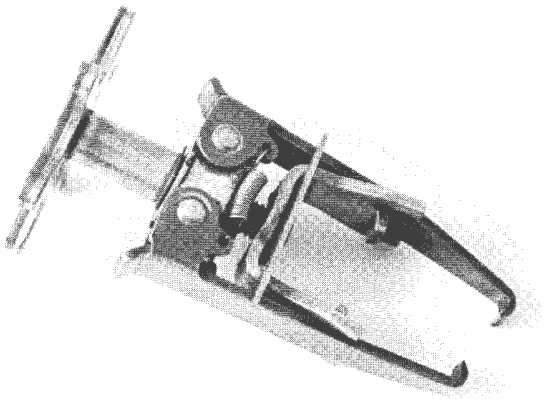
Battery post and cable cleaning tool
Oil filter spanner
Funnel (medium size)
Safety goggles
Jackstands (2)
Drain pan

Note: *If basic tune-ups are going to be part of routine maintenance, it will be necessary to purchase a good quality stroboscopic timing light and combination tachometer/dwell meter. Although they are included in the list of special tools, it is mentioned here because they are absolutely necessary for tuning most vehicles properly.*

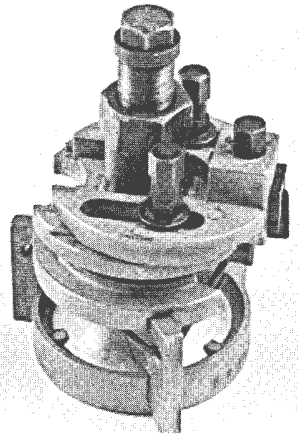
Repair and overhaul tool set

These tools are essential for anyone who plans to perform major repairs and are in addition to those in the maintenance and minor repair tool kit. Included is a comprehensive set of sockets which, though expensive, are invaluable because of their versatility, especially when various extensions and drives are available. We recommend the 1/2-inch drive over the 3/8-inch drive. Although the larger drive is bulky and more expensive, it has the capacity of accepting a very wide range of large sockets. Ideally, however, the mechanic should have a 3/8-inch drive set and a 1/2-inch drive set.

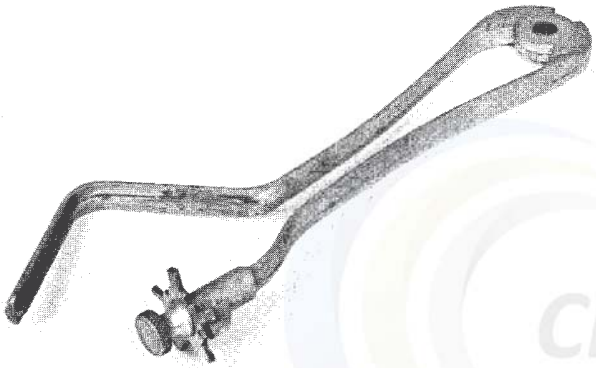
Socket set(s)
Reversible ratchet
Extension
Universal joint
Torque wrench (same size drive as sockets)
Ball peen hammer
Soft-face hammer (plastic/rubber)
Standard screwdriver
Standard screwdriver (stubby)
Phillips screwdriver
Phillips screwdriver (stubby - No. 2)
Pliers - vise grip
Pliers - lineman's
Pliers - needle nose
Pliers - snap-ring (internal and external)
Cold chisel
Scribe
Scraper (made from flattened copper tubing)
Centrepunch



Valve spring compressor



Ridge reamer



Piston ring groove cleaning tool

Ring removal/refitting tool

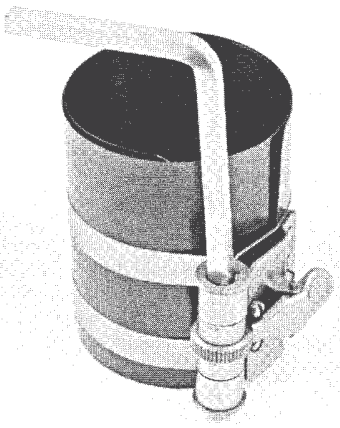
Pin punches
Steel rule/straightedge
Allen wrench set (4 mm to 10 mm)
A selection of files
Wire brush (large)
Jackstands (second set)
Jack (scissor or hydraulic type)

Note: *Another tool which is often useful is an electric drill with a chuck capacity of 10 mm and a set of good quality drill bits.*

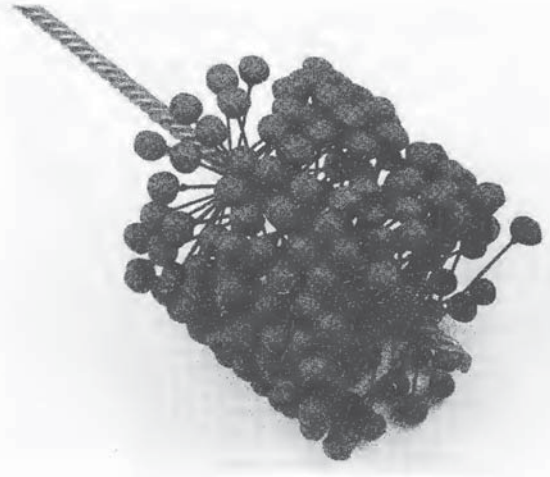
Special tools

The tools in this list include those which are not used regularly, are expensive to buy, or which need to be used in accordance with their manufacturer's instructions. Unless these tools will be used frequently, it is not very economical to purchase many of them. A consideration would be to split the cost and use between yourself and a friend or friends. In addition, most of these tools can be obtained from a tool rental shop on a temporary basis.

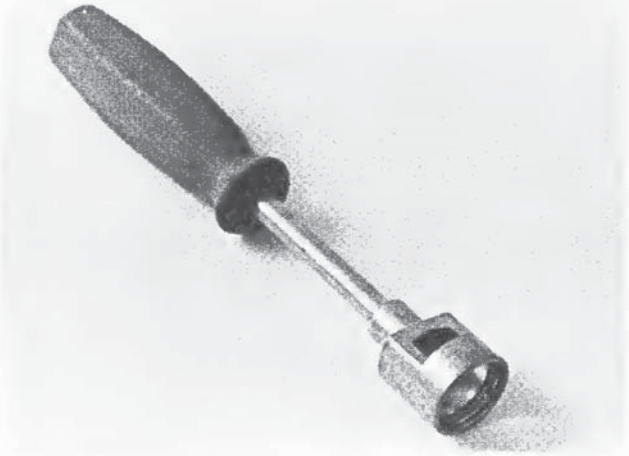
This list primarily contains only those tools and instruments widely available to the public, and not those special tools produced by the vehicle manufacturer for distribution to dealer service departments. Occasionally, references to the manufacturer's special tools are included in the text of this manual. Generally, an alternative method of doing the job without the special tool is offered. However, sometimes there is no alternative to their use. Where this is the case, and the tool cannot be purchased or borrowed, the work should be turned over to the dealer service department or an automotive repair shop.



Ring compressor



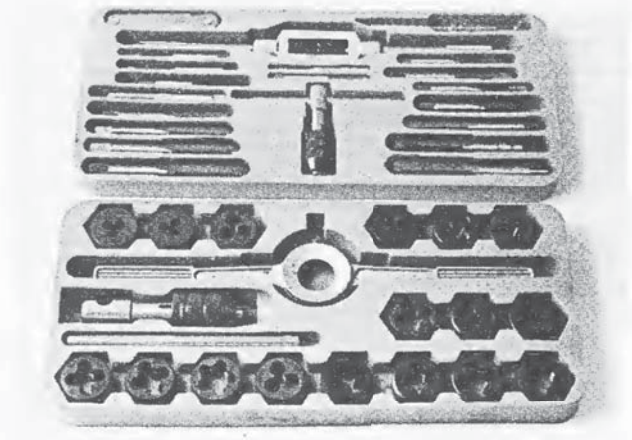
Cylinder hone



Brake hold-down spring tool

Torque angle gauge

Clutch plate alignment tool



Tap and die set

Valve spring compressor
Piston ring groove cleaning tool
Piston ring compressor
Piston ring refitting tool
Cylinder compression gauge
Cylinder ridge reamer
Cylinder surfacing hone
Cylinder bore gauge
Micrometers and/or dial calipers
Hydraulic lifter removal tool
Balljoint separator
Universal-type puller
Impact screwdriver
Dial indicator set
Stroboscopic timing light (inductive pick-up)
Hand operated vacuum/pressure pump
Tachometer/dwell meter
Universal electrical multimeter
Cable hoist
Brake spring removal and refitting tools
Floor jack

Buying tools

For the do-it-yourselfer who is just starting to get involved in vehicle maintenance and repair, there are a number of options available when purchasing tools. If maintenance and minor repair is the extent of the work to be done, the purchase of individual tools is satisfactory. If, on the other hand, extensive work is planned, it would be a good idea to purchase a modest tool set from one of the large retail chain stores. A set can usually be bought at a substantial savings over the individual tool prices, and they often come with a tool box. As additional tools are needed, add-on sets, individual tools and a larger tool box can be purchased to expand the tool selection. Building a tool set gradually allows the cost of the tools to be spread over a longer period of time and gives the mechanic the freedom to choose only those tools that will actually be used.

Tool stores will often be the only source-of some of the special tools that are needed, but regardless of where tools are bought, try to avoid cheap ones, especially when buying screwdrivers and sockets, because they won't last very long. The expense involved in renewing cheap tools will eventually be greater than the initial cost of quality tools.

Care and maintenance of tools

Good tools are expensive, so it makes sense to treat them with respect. Keep them clean and in useable condition and store them properly when not in use. Always wipe off any dirt, grease or metal chips before putting them away. Never leave tools lying around in the work area. Upon completion of a job, always check closely under the bonnet for tools that may have been left there so they won't get lost during a test drive.

Some tools, such as screwdrivers, pliers, spanners and sockets, can be hung on a panel mounted on the garage or workshop wall, while others should be kept in a tool box or tray. Measuring instruments, gauges, meters, etc. must be carefully stored where they cannot be damaged by weather or impact from other tools.

When tools are used with care and stored properly, they will last a very long time. Even with the best of care, though, tools will wear out if used frequently. When a tool is damaged or worn out, renew it. Subsequent jobs will be safer and more enjoyable if you do.

HOW TO REPAIR DAMAGED THREADS

Sometimes, the internal threads of a nut or bolt hole can become stripped, usually from overtightening. Stripping threads is an all-too-common occurrence, especially when working with aluminium parts, because aluminium is so soft that it easily strips out.

Usually, external or internal threads are only partially stripped. After they've been cleaned up with a tap or die, they'll still work. Sometimes, however, threads are badly damaged. When this happens, you've got three choices:

1) *Drill and tap the hole to the next suitable oversize and refit a larger diameter bolt, screw or stud.*
2) *Drill and tap the hole to accept a threaded plug, then drill and tap the plug to the original screw size. You can also buy a plug already threaded to the original size. Then you simply drill a hole to the specified size, then run the threaded plug into the hole with a bolt and jam nut. Once the plug is fully seated, remove the jam nut and bolt.*
3) *The third method uses a patented thread repair kit like Heli-Coil or Slimsert. These easy-to-use kits are designed to repair damaged threads in straight-through holes and blind holes. Both are available as kits which can handle a variety of sizes and thread patterns. Drill the hole, then tap it with the special included tap. Fit the Heli-Coil and the hole is back to its original diameter and thread pitch.*

Regardless of which method you use, be sure to proceed calmly and carefully. A little impatience or carelessness during one of these relatively simple procedures can ruin your whole day's work and cost you a bundle if you wreck an expensive part.

WORKING FACILITIES

Not to be overlooked when discussing tools is the workshop. If anything more than routine maintenance is to be carried out, some sort of suitable work area is essential.

It is understood, and appreciated, that many home mechanics do not have a good workshop or garage available, and end up removing an engine or doing major repairs outside. It is recommended, however, that the overhaul or repair be completed under the cover of a roof.

A clean, flat workbench or table of comfortable working height is an absolute necessity. The workbench should be equipped with-a vise that has a jaw opening of at least 10-cm.

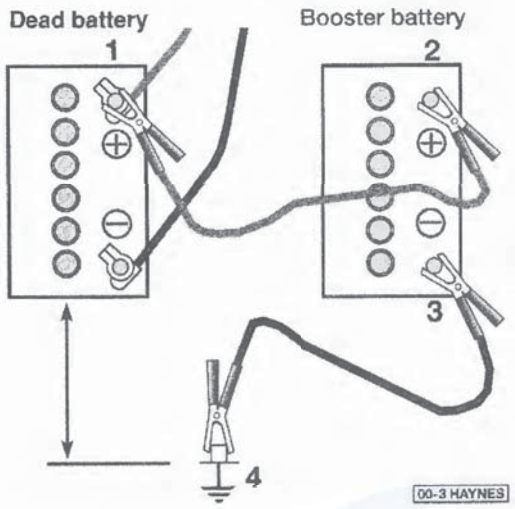
As mentioned previously, some clean, dry storage space is also required for tools, as well as the lubricants, fluids, cleaning solvents, etc. which soon become necessary.

Sometimes waste oil and fluids, drained from the engine or cooling system during normal maintenance or repairs, present a disposal problem. To avoid pouring them on the ground or into a sewage system, pour the used fluids into large containers, seal them with caps and take them to an authorised disposal site or recycling centre. Plastic jugs, such as old antifreeze containers, are ideal for this purpose.

Always keep a supply of old newspapers and clean rags available. Old towels are excellent for mopping up spills. Many mechanics use rolls of paper towels for most work because they are readily available and disposable. To help keep the area under the vehicle clean, a large cardboard box can be cut open and flattened to protect the garage or shop floor.

Whenever working over a painted surface, such as when leaning over a fender to service something under the bonnet, always cover it with an old blanket or bedspread to protect the finish. Vinyl covered pads, made especially for this purpose, are available at auto parts stores.

Booster battery (jump) starting



Make the booster battery cable connections in the numerical order shown (note that the negative cable of the booster battery is NOT attached to the negative terminal of the dead battery)

Observe these precautions when using a booster battery to start a vehicle:

a) Before connecting the booster battery, make sure the ignition switch is in the Off position.
b) Turn off the lights, heater and other electrical loads.
c) Your eyes should be shielded. Safety goggles are a good idea.
d) Make sure the booster battery is the same voltage as the dead one in the vehicle.
e) The two vehicles MUST NOT TOUCH each other!
f) Make sure the transmission is in Neutral (manual) or Park (automatic).
g) If the booster battery is not a maintenance-free type, remove the vent caps and lay a cloth over the vent holes.

Connect the red jumper cable to the positive (+) terminals of each battery (see illustration).

Connect one end of the black jumper cable to the negative (-) terminal of the booster battery. The other end of this cable should be connected to a good earth on the vehicle to be started, such as a bolt or bracket on the body.

Start the engine using the booster battery, then, with the engine running at idle speed, disconnect the jumper cables in the reverse order of connection.

Jacking and towing

JACKING

Place the jack under the side of the vehicle and adjust the jack height so it fits under the car in the correct position. The jack must be nearest to the wheel being fitted. Note that there is a front and rear jacking point on each side of the car identified by a semi-circular cutout in the lower body flange (see illustration). The jack must engage the flange at this point.

Block the wheel diagonally opposite the wheel being raised. Loosen the lug nuts on the wheel being removed.

Operate the jack until the tyre clears the ground. Remove the lug nuts and pull the wheel off. Fit it with the spare.

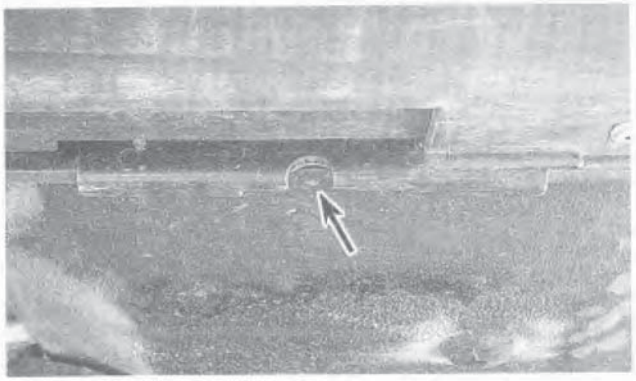
TOWING

It is always best to have the vehicle towed by an experienced tow truck operator. The flat-bed type of tow truck, which hauls the vehicle with all four wheels off the ground is the safest.

Manual transmission-equipped vehicles can be towed in Neutral with an approved tow device such as a tow bar. Vehicles with automatic transmissions should not be towed for distances of more than 55 kilometres at low speeds (up to 55 kph). If you wish to tow further or faster, the driveshaft must be removed. Refer to Chapter 8. The driveshaft must first be removed also if the transmission has been damaged.

When towing, always use an independent safety chain.

In extreme emergencies, the car can be towed for short distances with a chain or rope attached to the towing eyes that are on the front frame. It might be necessary to position a block of wood beneath the radiator support so that the chain or rope doesn't damage any sheet metal. The driver must remain in the car to operate the steering and brakes. Remember that the power steering and brakes will not work with the engine turned off. Turn the key to ACC before starting.



A semi-circular cutout jacking point (arrow) is located in the lower body flange near each wheel

Anti-theft radio system

GENERAL INFORMATION

1 These models are equipped with radio systems that include an anti-theft feature that will render the unit inoperative if stolen. If the power source to the radio is cut with the anti-theft feature activated, the radio will be inoperative. Even if the power source is immediately re-connected, the radio will not function.

2 If your vehicle is equipped with this anti-theft system, do not disconnect the battery, remove the radio or disconnect related components unless you have first entered your Personal Identification Number (PIN).

ENTERING YOUR PIN

3 Turn the ignition switch to the Accessory (ACC) position. The display will show "1".

4 Press the radio buttons in order and enter your PIN. The radio will begin playing, indicating that the PIN has been entered correctly.

5 If the incorrect PIN was entered, "2" will be displayed. Repeat the procedure to enter the correct PIN.

6 If three incorrect PINs are entered, the display will show "- - -", and you must wait one hour with the battery connected before entering the correct PIN.

Automotive chemicals and lubricants

A number of automotive chemicals and lubricants are available for use during vehicle maintenance and repair. They include a wide variety of products ranging from cleaning solvents and degreasers to lubricants and protective sprays for rubber, plastic and vinyl.

CLEANERS

Carburettor cleaner and choke cleaner is a strong solvent for gum, varnish and carbon. Most carburettor cleaners leave a dry-type lubricant film which will not harden or gum up. Because of this film it is not recommended for use on electrical components.

Brake system cleaner is used to remove brake dust, grease and brake fluid from the brake system, where clean surfaces are absolutely necessary. It leaves no residue and often eliminates brake squeal caused by contaminants.

Electrical cleaner removes oxidation, corrosion and carbon deposits from electrical contacts, restoring full current flow. It can also be used to clean spark plugs, carburettor jets, voltage regulators and other parts where an oil-free surface is desired.

Demoisturants remove water and moisture from electrical components such as alternators, voltage regulators, electrical connectors and fuse blocks. They are non-conductive and non-corrosive.

Degreasers are heavy-duty solvents used to remove grease from the outside of the engine and from chassis components. They can be sprayed or brushed on and, depending on the type, are rinsed off either with water or solvent.

LUBRICANTS

Motor oil is the lubricant formulated for use in engines. It normally contains a wide variety of additives to prevent corrosion and reduce foaming and wear. Motor oil comes in various weights (viscosity ratings) from 0 to 50. The recommended weight of the oil depends on the season, temperature and the demands on the engine. Light oil is used in cold climates and under light load conditions. Heavy oil is used in hot climates and where high loads are encountered. Multi-viscosity oils are designed to have characteristics of both light and heavy oils and are available in a number of weights from 5W-20 to 20W-50.

Gear oil is designed to be used in differentials, manual transmissions and other areas where high-temperature lubrication is required.

Chassis and wheel bearing grease is a heavy grease used where increased loads and friction are encountered, such as for wheel bearings, balljoints, tie-rod ends and universal joints.

High-temperature wheel bearing grease is designed to withstand the extreme temperatures encountered by wheel bearings in disc brake equipped vehicles. It usually contains molybdenum disulfide (moly), which is a dry-type lubricant.

White grease is a heavy grease for metal-to-metal applications where water is a problem. White grease stays soft under both low and high temperatures (usually from -56 to +106-degrees C), and will not wash off or dilute in the presence of water.

Assembly lube is a special extreme pressure lubricant, usually containing moly, used to lubricate high-load parts (such as main and rod bearings and cam lobes) for initial start-up of a new engine. The assembly lube lubricates the parts without being squeezed out or washed away until the engine oiling system begins to function.

Silicone lubricants are used to protect rubber, plastic, vinyl and nylon parts.

Graphite lubricants are used where oils cannot be used due to contamination problems, such as in locks. The dry graphite will lubricate metal parts while remaining uncontaminated by dirt, water, oil or acids. It is electrically conductive and will not foul electrical contacts in locks such as the ignition switch.

Moly penetrants loosen and lubricate seized, rusted and corroded fasteners and prevent future rusting or freezing.

Heat-sink grease is a special electrically non-conductive grease that is used for mounting electronic ignition modules where it is essential that heat is transferred away from the module.

SEALANTS

RTV sealant is one of the most widely used gasket compounds. Made from silicone, RTV is air curing, it seals, bonds, waterproofs, fills surface irregularities, remains flexible, doesn't shrink, is relatively easy to remove, and is used as a supplementary sealer with almost all low and medium temperature gaskets.

Anaerobic sealant is much like RTV in that it can be used either to seal gaskets or to form gaskets by itself. It remains flexible, is solvent resistant and fills surface imperfections. The difference between an anaerobic sealant and an RTV-type sealant is in the curing. RTV cures when exposed to air, while an anaerobic sealant cures only in the absence of air. This means that an anaerobic sealant cures only after the assembly of parts, sealing them together.

Thread and pipe sealant is used for sealing hydraulic and pneumatic fittings and vacuum lines. It is usually made from a Teflon compound, and comes in a spray, a paint-on liquid and as a wrap-around tape.

CHEMICALS

Anti-seize compound prevents seizing, galling, cold welding, rust and corrosion in fasteners. High-temperature anti-seize, usually made with copper and graphite lubricants, is used for exhaust system and exhaust manifold bolts.

Anaerobic locking compounds are used to keep fasteners from vibrating or working loose and cure only after installation, in the absence of air. Medium strength locking compound is used for small nuts, bolts and screws that may be removed later. High-strength locking compound is for large nuts, bolts and studs which aren't removed on a regular basis.

Oil additives range from viscosity index improvers to chemical treatments that claim to reduce internal engine friction. It should be noted that most oil manufacturers caution against using additives with their oils.

Fuel additives perform several functions, depending on their chemical makeup. They usually contain solvents that help dissolve gum and varnish that build up on carburettor, fuel injection and inlet parts. They also serve to break down carbon deposits that form on the inside surfaces of the combustion chambers. Some additives contain upper cylinder lubricants for valves and piston rings, and others contain chemicals to remove condensation from the fuel tank.

MISCELLANEOUS

Brake fluid is specially formulated hydraulic fluid that can withstand the heat and pressure encountered in brake systems. Care must be taken so this fluid does not come in contact with painted surfaces or plastics. An opened container should always be resealed to prevent contamination by water or dirt.

Weatherstrip adhesive is used to bond weatherstripping around doors, windows and luggage compartment lids. It is sometimes used to attach trim pieces.

Undercoating is a petroleum-based, tar-like substance that is designed to protect metal surfaces on the underside of the vehicle from corrosion. It also acts as a sound-deadening agent by insulating the bottom of the vehicle.

Waxes and polishes are used to help protect painted and plated surfaces from the weather. Different types of paint may require the use of different types of wax and polish. Some polishes utilise a chemical or abrasive cleaner to help remove the top layer of oxidised (dull) paint on older vehicles. In recent years many non-wax polishes that contain a wide variety of chemicals such as polymers and silicones have been introduced. These non-wax polishes are usually easier to apply and last longer than conventional waxes and polishes.

Safety first!

Regardless of how enthusiastic you may be about getting on with the job at hand, take the time to ensure that your safety is not jeopardised. A moment's lack of attention can result in an accident, as can failure to observe certain simple safety precautions. The possibility of an accident will always exist, and the following points should not be considered a comprehensive list of all dangers. Rather, they are intended to make you aware of the risks and to encourage a safety conscious approach to all work you carry out on your vehicle.

ESSENTIAL DOS AND DON'TS

DON'T rely on a jack when working under the vehicle. Always use approved jackstands to support the weight of the vehicle and place them under the recommended lift or support points.

DON'T attempt to loosen extremely tight fasteners (i.e. wheel lug nuts) while the vehicle is on a jack - it may fall.

DON'T start the engine without first making sure that the transmission is in Neutral (or Park where applicable) and the parking brake is set.

DON'T remove the radiator cap from a hot cooling system - let it cool or cover it with a cloth and release the pressure gradually.

DON'T attempt to drain the engine oil until you are sure it has cooled to the point that it will not burn you.

DON'T touch any part of the engine or exhaust system until it has cooled sufficiently to avoid burns.

DON'T siphon toxic liquids such as petrol, antifreeze and brake fluid by mouth, or allow them to remain on your skin.

DON'T inhale brake lining dust - it is potentially hazardous (see Asbestos below).

DON'T allow spilled oil or grease to remain on the floor - wipe it up before someone slips on it.

DON'T use loose fitting spanners or other tools which may slip and cause injury.

DON'T push on spanners when loosening or tightening nuts or bolts. Always try to pull the spanner toward you. If the situation calls for pushing the spanner away, push with an open hand to avoid scraped knuckles if the spanner should slip.

DON'T attempt to lift a heavy component alone - get someone to help you.

DON'T rush or take unsafe shortcuts to finish a job.

DON'T allow children or animals in or around the vehicle while you are working on it.

DO wear eye protection when using power tools such as a drill, sander, bench grinder, etc. and when working under a vehicle.

DO keep loose clothing and long hair well out of the way of moving parts.

DO make sure that any hoist used has a safe working load rating adequate for the job.

DO get someone to check on you periodically when working alone on a vehicle.

DO carry out work in a logical sequence and make sure that everything is correctly assembled and tightened.

DO keep chemicals and fluids tightly capped and out of the reach of children and pets.

DO remember that your vehicle's safety affects that of yourself and others. If in doubt on any point, get professional advice.

ASBESTOS

Certain friction, insulating, sealing, and other products - such as brake linings, brake bands, clutch linings, torque converters, gaskets, etc. - may contain asbestos. Extreme care must be taken to avoid inhalation of dust from such products, since it is hazardous to health. If in doubt, assume that they do contain asbestos.

FIRE

Remember at all times that petrol is highly flammable. Never smoke or have any kind of open flame around when working on a vehicle. But the risk does not end there. A spark caused by an electrical short circuit, by two metal surfaces contacting each other, or even by static electricity built up in your body under certain conditions, can ignite petrol vapours, which in a confined space are highly explosive. Do not, under any circumstances, use petrol for cleaning parts. Use an approved safety solvent.

Always disconnect the battery earth (-) cable at the battery before working on any part of the fuel system or electrical system. Never risk spilling fuel on a hot engine or exhaust component. It is strongly recommended that a fire extinguisher suitable for use on fuel and electrical fires be kept handy in the garage or workshop at all times. Never try to extinguish a fuel or electrical fire with water.

FUMES

Certain fumes are highly toxic and can quickly cause unconsciousness and even death if inhaled to any extent. Petrol vapour falls into this category, as do the vapours from some cleaning solvents. Any draining or pouring of such volatile fluids should be done in a well ventilated area.

When using cleaning fluids and solvents, read the instructions on the container carefully. Never use materials from unmarked containers.

Never run the engine in an enclosed space, such as a garage. Exhaust fumes contain carbon monoxide, which is extremely poisonous. If you need to run the engine, always do so in the open air, or at least have the rear of the vehicle outside the work area.

If you are fortunate enough to have the use of an inspection pit, never drain or pour petrol and never run the engine while the vehicle is over the pit. The fumes, being heavier than air, will concentrate in the pit with possibly lethal results.

THE BATTERY

Never create a spark or allow a bare light bulb near a battery. They normally give off a certain amount of hydrogen gas, which is highly explosive.

Always disconnect the battery earth (-) cable at the battery before working on the fuel or electrical systems.

If possible, loosen the filler caps or cover when charging the battery from an external source (this does not apply to sealed or maintenance-free batteries). Do not charge at an excessive rate or the battery may burst.

Take care when adding water to a non maintenance-free battery and when carrying a battery. The electrolyte, even when diluted, is very corrosive and should not be allowed to contact clothing or skin.

Always wear eye protection when cleaning the battery to prevent the caustic deposits from entering your eyes.

HOUSEHOLD CURRENT

When using an electric power tool, inspection light, etc., which operates on household current, always make sure that the tool is correctly connected to its plug and that, where necessary, it is properly earthed. Do not use such items in damp conditions and, again, do not create a spark or apply excessive heat in the vicinity of fuel or fuel vapour.

SECONDARY IGNITION SYSTEM VOLTAGE

A severe electric shock can result from touching certain parts of the ignition system (such as the spark plug wires) when the engine is running or being cranked, particularly if components are damp or the insulation is defective. In the case of an electronic ignition system, the secondary system voltage is much higher and could prove fatal.

HYDROFLUORIC ACID

This extremely corrosive acid is formed when certain types of synthetic rubber, found in some O-rings, oil seals, fuel hoses, etc. are exposed to temperatures above 750-degrees F (400-degrees C). The rubber changes into a charred or sticky substance containing the acid. Once formed, the acid remains dangerous for years. If it gets onto the skin, it may be necessary to amputate the limb concerned.

When dealing with a vehicle which has suffered a fire, or with components salvaged from such a vehicle, wear protective gloves and discard them after use.

Conversion factors

Length (distance)						
Inches (in)	X	25.4	= Millimetres (mm)	X	0.0394	= Inches (in)
Feet (ft)	X	0.305	= Metres (m)	X	3.281	= Feet (ft)
Miles	X	1.609	= Kilometres (km)	X	0.621	= Miles
Volume (capacity)						
Cubic inches (cu in; in^3)	X	16.387	= Cubic centimetres (cc; cm^3)	X	0.061	= Cubic inches (cu in; in^3)
Imperial pints (Imp pt)	X	0.568	= Litres (l)	X	1.76	= Imperial pints (Imp pt)
Imperial quarts (Imp qt)	X	1.137	= Litres (l)	X	0.88	= Imperial quarts (Imp qt)
Imperial quarts (Imp qt)	X	1.201	= US quarts (US qt)	X	0.833	= Imperial quarts (Imp qt)
US quarts (US qt)	X	0.946	= Litres (l)	X	1.057	= US quarts (US qt)
Imperial gallons (Imp gal)	X	4.546	= Litres (l)	X	0.22	= Imperial gallons (Imp gal)
Imperial gallons (Imp gal)	X	1.201	= US gallons (US gal)	X	0.833	= Imperial gallons (Imp gal)
US gallons (US gal)	X	3.785	= Litres (l)	X	0.264	= US gallons (US gal)
Mass (weight)						
Ounces (oz)	X	28.35	= Grams (g)	X	0.035	= Ounces (oz)
Pounds (lb)	X	0.454	= Kilograms (kg)	X	2.205	= Pounds (lb)
Force						
Ounces-force (ozf; oz)	X	0.278	= Newtons (N)	X	3.6	= Ounces-force (ozf; oz)
Pounds-force (lbf; lb)	X	4.448	= Newtons (N)	X	0.225	= Pounds-force (lbf; lb)
Newtons (N)	X	0.1	= Kilograms-force (kgf; kg)	X	9.81	= Newtons (N)
Pressure						
Pounds-force per square inch (psi; lbf/in^2; lb/in^2)	X	0.070	= Kilograms-force per square centimetre (kgf/cm^2; kg/cm^2)	X	14.223	= Pounds-force per square inch (psi; lbf/in^2; lb/in^2)
Pounds-force per square inch (psi; lbf/in^2; lb/in^2)	X	0.068	= Atmospheres (atm)	X	14.696	= Pounds-force per square inch (psi; lbf/in^2; lb/in^2)
Pounds-force per square inch (psi; lbf/in^2; lb/in^2)	X	0.069	= Bars	X	14.5	= Pounds-force per square inch (psi; lbf/in^2; lb/in^2)
Pounds-force per square inch (psi; lbf/in^2; lb/in^2)	X	6.895	= Kilopascals (kPa)	X	0.145	= Pounds-force per square inch (psi; lbf/in^2; lb/in^2)
Kilopascals (kPa)	X	0.01	= Kilograms-force per square centimetre (kgf/cm^2; kg/cm^2)	X	98.1	= Kilopascals (kPa)
Torque (moment of force)						
Pounds-force inches (lbf in; lb in)	X	1.152	= Kilograms-force centimetre (kgf cm; kg cm)	X	0.868	= Pounds-force inches (lbf in; lb in)
Pounds-force inches (lbf in; lb in)	X	0.113	= Newton metres (Nm)	X	8.85	= Pounds-force inches (lbf in; lb in)
Pounds-force inches (lbf in; lb in)	X	0.083	= Pounds-force feet (lbf ft; lb ft)	X	12	= Pounds-force inches (lbf in; lb in)
Pounds-force feet (lbf ft; lb ft)	X	0.138	= Kilograms-force metres (kgf m; kg m)	X	7.233	= Pounds-force feet (lbf ft; lb ft)
Pounds-force feet (lbf ft; lb ft)	X	1.356	= Newton metres (Nm)	X	0.738	= Pounds-force feet (lbf ft; lb ft)
Newton metres (Nm)	X	0.102	= Kilograms-force metres (kgf m; kg m)	X	9.804	= Newton metres (Nm)
Vacuum						
Inches mercury (in. Hg)	X	3.377	= Kilopascals (kPa)	X	0.2961	= Inches mercury
Inches mercury (in. Hg)	X	25.4	= Millimetres mercury (mm Hg)	X	0.0394	= Inches mercury
Power						
Horsepower (hp)	X	745.7	= Watts (W)	X	0.0013	= Horsepower (hp)
Velocity (speed)						
Miles per hour (miles/hr; mph)	X	1.609	= Kilometres per hour (km/hr; kph)	X	0.621	= Miles per hour (miles/hr; mph)
*Fuel consumption**						
Miles per gallon, Imperial (mpg)	X	0.354	= Kilometres per litre (km/l)	X	2.825	= Miles per gallon, Imperial (mpg)
Miles per gallon, US (mpg)	X	0.425	= Kilometres per litre (km/l)	X	2.352	= Miles per gallon, US (mpg)

Temperature

Degrees Fahrenheit = (°C x 1.8) + 32

Degrees Celsius (Degrees Centigrade; °C) = (°F - 32) x 0.56

**It is common practice to convert from miles per gallon (mpg) to litres/100 kilometres (l/100km), where mpg (Imperial) x l/100 km = 282 and mpg (US) x l/100 km = 235*

Fraction/Decimal/Millimetre Equivalents

DECIMALS TO MILLIMETRES

Decimal	mm	Decimal	mm
0.001	0.0254	0.500	12.7000
0.002	0.0508	0.510	12.9540
0.003	0.0762	0.520	13.2080
0.004	0.1016	0.530	13.4620
0.005	0.1270	0.540	13.7160
0.006	0.1524	0.550	13.9700
0.007	0.1778	0.560	14.2240
0.008	0.2032	0.570	14.4780
0.009	0.2286	0.580	14.7320
		0.590	14.9860
0.010	0.2540		
0.020	0.5080		
0.030	0.7620		
0.040	1.0160	0.600	15.2400
0.050	1.2700	0.610	15.4940
0.060	1.5240	0.620	15.7480
0.070	1.7780	0.630	16.0020
0.080	2.0320	0.640	16.2560
0.090	2.2860	0.650	16.5100
		0.660	16.7640
0.100	2.5400	0.670	17.0180
0.110	2.7940	0.680	17.2720
0.120	3.0480	0.690	17.5260
0.130	3.3020		
0.140	3.5560		
0.150	3.8100		
0.160	4.0640	0.700	17.7800
0.170	4.3180	0.710	18.0340
0.180	4.5720	0.720	18.2880
0.190	4.8260	0.730	18.5420
		0.740	18.7960
0.200	5.0800	0.750	19.0500
0.210	5.3340	0.760	19.3040
0.220	5.5880	0.770	19.5580
0.230	5.8420	0.780	19.8120
0.240	6.0960	0.790	20.0660
0.250	6.3500		
0.260	6.6040		
0.270	6.8580	0.800	20.3200
0.280	7.1120	0.810	20.5740
0.290	7.3660	0.820	21.8280
		0.830	21.0820
0.300	7.6200	0.840	21.3360
0.310	7.8740	0.850	21.5900
0.320	8.1280	0.860	21.8440
0.330	8.3820	0.870	22.0980
0.340	8.6360	0.880	22.3520
0.350	8.8900	0.890	22.6060
0.360	9.1440		
0.370	9.3980		
0.380	9.6520		
0.390	9.9060		
		0.900	22.8600
0.400	10.1600	0.910	23.1140
0.410	10.4140	0.920	23.3680
0.420	10.6680	0.930	23.6220
0.430	10.9220	0.940	23.8760
0.440	11.1760	0.950	24.1300
0.450	11.4300	0.960	24.3840
0.460	11.6840	0.970	24.6380
0.470	11.9380	0.980	24.8920
0.480	12.1920	0.990	25.1460
0.490	12.4460	1.000	25.4000

FRACTIONS TO DECIMALS TO MILLIMETRES

Fraction	Decimal	mm	Fraction	Decimal	mm
1/64	0.0156	0.3969	33/64	0.5156	13.0969
1/32	0.0312	0.7938	17/32	0.5312	13.4938
3/64	0.0469	1.1906	35/64	0.5469	13.8906
1/16	0.0625	1.5875	9/16	0.5625	14.2875
5/64	0.0781	1.9844	37/64	0.5781	14.6844
3/32	0.0938	2.3812	19/32	0.5938	15.0812
7/64	0.1094	2.7781	39/64	0.6094	15.4781
1/8	0.1250	3.1750	5/8	0.6250	15.8750
9/64	0.1406	3.5719	41/64	0.6406	16.2719
5/32	0.1562	3.9688	21/32	0.6562	16.6688
11/64	0.1719	4.3656	43/64	0.6719	17.0656
3/16	0.1875	4.7625	11/16	0.6875	17.4625
13/64	0.2031	5.1594	45/64	0.7031	17.8594
7/32	0.2188	5.5562	23/32	0.7188	18.2562
15/64	0.2344	5.9531	47/64	0.7344	18.6531
1/4	0.2500	6.3500	3/4	0.7500	19.0500
17/64	0.2656	6.7469	49/64	0.7656	19.4469
9/32	0.2812	7.1438	25/32	0.7812	19.8438
19/64	0.2969	7.5406	51/64	0.7969	20.2406
5/16	0.3125	7.9375	13/16	0.8125	20.6375
21/64	0.3281	8.3344	53/64	0.8281	21.0344
11/32	0.3438	8.7312	27/32	0.8438	21.4312
23/64	0.3594	9.1281	55/64	0.8594	21.8281
3/8	0.3750	9.5250	7/8	0.8750	22.2250
25/64	0.3906	9.9219	57/64	0.8906	22.6219
13/32	0.4062	10.3188	29/32	0.9062	23.0188
27/64	0.4219	10.7156	59/64	0.9219	23.4156
7/16	0.4375	11.1125	15/16	0.9375	23.8125
29/64	0.4531	11.5094	61/64	0.9531	24.2094
15/32	0.4688	11.9062	31/32	0.9688	24.6062
31/64	0.4844	12.3031	63/64	0.9844	25.0031
1/2	0.5000	12.7000	1	1.0000	25.4000

Troubleshooting

Contents

This Section provides an easy reference guide to the more common problems that may occur during the operation of your vehicle. Various symptoms and their probable causes are grouped under headings denoting components or systems, such as Engine, Cooling system, etc. They also refer to the Chapter and/or Section that deals with the problem.

Remember that successful trouble-shooting isn't a mysterious art practiced only by professional mechanics, it's simply the result of knowledge combined with an intelligent, systematic approach to a problem. Always use a process of elimination starting with the simplest solution and working through to the most complex - and never overlook the obvious. Anyone can run the fuel tank dry or leave the lights on overnight, so don't assume that you're exempt from such oversights.

Finally, always establish a clear idea why a problem has occurred and take steps to ensure that it doesn't happen again. If the electrical system fails because of a poor connection, check all other connections in the system to make sure they don't fail as well. If a particular fuse continues to blow, find out why - don't just go on renewing fuses. Remember, failure of a small component can often be indicative of potential failure or incorrect functioning of a more important component or system.

Engine

1 Engine will not rotate when attempting to start

1 Battery terminal connections loose or corroded. Check the cable terminals at the battery; tighten cable clamp and/or clean off corrosion as necessary (see Chapter 1).
2 Battery discharged or faulty. If the cable ends are clean and tight on the battery posts, turn the key to the On position and switch on the headlights or windshield wipers. If they won't run, the battery is discharged.
3 Automatic transmission not engaged in park (P) or Neutral (N).
4 Broken, loose or disconnected wires in the starting circuit. Inspect all wires and connectors at the battery, starter solenoid and ignition switch (on steering column).
5 Starter motor pinion jammed in driveplate ring gear. Remove starter (Chapter 5) and inspect pinion and driveplate (Chapter 2).
6 Starter solenoid faulty (Chapter 5).
7 Starter motor faulty (Chapter 5).
8 Ignition switch faulty (Chapter 12).
9 Engine seized. Try to turn the crankshaft with a large socket and breaker bar on the pulley bolt.

2 Engine rotates but will not start

1 Fuel tank empty.
2 Battery discharged (engine rotates slow-ly).
3 Battery terminal connections loose or corroded.
4 Fuel not reaching fuel injector(s). Check for clogged fuel filter or lines and defective fuel pump. Also make sure the tank vent lines aren't clogged (Chapter 4).
5 Low cylinder compression. Check as described in Chapter 2.
6 Water in fuel. Drain tank and fill with new fuel.
7 Defective ignition coil(s), module or distributor (V8 models) (Chapter 5).
8 Dirty or clogged fuel injector(s) (Chap-ter 4).
9 Wet or damaged ignition components (Chapters 1 and 5).
10 Worn, faulty or incorrectly gapped spark plugs (Chapter 1).
11 Broken, loose or disconnected wires in the starting circuit (see previous Section).
12 Broken or faulty coil (Chapter 5).
13 Timing chain failure or wear affecting valve timing (Chapter 2).
14 Fuel injection or engine control systems failure (Chapters 4 and 6).

3 Starter motor operates without turning engine

1 Starter pinion sticking. Remove the starter (Chapter 5) and inspect.
2 Starter pinion or driveplate teeth worn or broken. Remove the inspection cover and inspect.

4 Engine hard to start when cold

1 Battery discharged or low. Check as described in Chapter 1.
2 Fuel not reaching the fuel injectors. Check the fuel filter, lines and fuel pump (Chapters 1 and 4).
3 Defective spark plugs (Chapter 1).
4 Defective engine coolant temperature sensor (Chapter 6).
5 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

5 Engine hard to start when hot

1 Air filter dirty (Chapter 1).
2 Fuel not reaching the fuel injectors (see Chapter 4). Check for a vapour lock situation, brought about by clogged fuel tank vent lines.
3 Bad engine earth connection.
4 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

6 Starter motor noisy or engages roughly

1 Pinion or driveplate teeth worn or broken. Remove the inspection cover on the left side of the engine and inspect.
2 Starter motor mounting bolts loose or missing.

7 Engine starts but stops immediately

1 Loose or damaged wire harness connections at coil or alternator.
2 Inlet manifold vacuum leaks. Make sure all mounting bolts/nuts are tight and all vacuum hoses connected to the manifold are attached properly and in good condition.
3 Insufficient fuel pressure (see Chapter 4).
4 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

8 Engine 'lopes' while idling or idles erratically

1 Vacuum leaks. Check mounting bolts at the inlet manifold for tightness. Make sure that all vacuum hoses are connected and in good condition. Use a stethoscope or a length of fuel hose held against your ear to listen for vacuum leaks while the engine is running. A hissing sound will be heard. A soapy water solution will also detect leaks. Check the inlet manifold gasket surfaces.
2 Leaking EGR valve or plugged PCV valve (see Chapters 1 and 6).
3 Air filter clogged (Chapter 1).
4 Fuel pump not delivering sufficient fuel (Chapter 4).
5 Leaking head gasket. Perform a cylinder compression check (Chapter 2).
6 Camshaft lobes worn (Chapter 2).
7 Valves burned or otherwise leaking (Chapter 2).
8 Ignition system not operating properly (Chapters 1 and 5).
9 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

9 Engine misses at idle speed

1 Spark plugs faulty or not gapped properly (Chapter 1).
2 Faulty spark plug wires (Chapter 1).
3 Short circuits in ignition, coil or spark plug wires (Chapters 1 and 5).
4 Sticking or faulty emissions systems (see Chapter 6).
5 Clogged fuel filter and/or foreign matter in fuel. Remove the fuel filter (Chapter 1) and inspect.
6 Vacuum leaks at inlet manifold or hose connections. Check as described in Section 8.
7 Incorrect idle speed (Chapter 4).
8 Low or uneven cylinder compression. Check as described in Chapter 2.
9 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

10 Excessively high idle speed

1 Sticking throttle linkage (Chapter 4).
2 Vacuum leaks at inlet manifold or hose connections. Check as described in Section 8.
3 Fuel injection or engine control systems (IAC) malfunction (Chapters 4 and 6).
4 Incorrect ignition timing (V8 models).

11 Battery will not hold a charge

1 Alternator drivebelt defective or not adjusted properly (Chapter 1).
2 Battery cables loose or corroded (Chapter 1).
3 Alternator not charging properly (Chapter 5).
4 Loose, broken or faulty wires in the charging circuit (Chapter 5).
5 Short circuit causing a continuous drain on the battery.
6 Battery defective internally.

12 Alternator light stays on

1 Fault in alternator or charging circuit (Chapter 5).
2 Alternator drivebelt defective or not properly adjusted (Chapter 1).

13 Alternator light fails to come on when key is turned on

1 Faulty bulb (Chapter 12).
2 Defective alternator (Chapter 5).
3 Fault in the dash wiring or bulb holder (Chapter 12).

14 Engine misses throughout driving speed range

1 Fuel filter clogged and/or impurities in the fuel system. Check fuel filter (Chapter 1) or clean system (Chapter 4).
2 Faulty or incorrectly gapped spark plugs (Chapter 1).
3 Defective spark plug wires (Chapter 1).
4 Emissions system components faulty (Chapter 6).
5 Low or uneven cylinder compression pressures. Check as described in Chapter 2.
6 Weak or faulty ignition coil (Chapter 5).
7 Weak or faulty ignition system (Chapter 5).
8 Vacuum leaks at inlet manifold or vacuum hoses (see Section 8).
9 Dirty or clogged fuel injector(s) (Chapter 4).
10 Leaky EGR valve (Chapter 6).
11 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

15 Hesitation or stumble during acceleration

1 Ignition system not operating properly (Chapter 5).
2 Dirty or clogged fuel injector(s) (Chapter 4B).
3 Low fuel pressure. Check for proper operation of the fuel pump and for restrictions in the fuel filter and lines (Chapter 4).
4 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

16 Engine stalls

1 Fuel filter clogged and/or water and impurities in the fuel system (Chapter 1).
2 Damaged or wet wires.
3 Emissions system components faulty (Chapter 6).
4 Faulty or incorrectly gapped spark plugs (Chapter 1). Also check the spark plug wires (Chapter 1).
5 Vacuum leak at the inlet manifold or vacuum hoses. Check as described in Section 8.
6 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

17 Engine lacks power

1 Faulty or incorrectly gapped spark plugs (Chapter 1).
2 Air filter dirty (Chapter 1).
3 Faulty ignition coil system (Chapter 5).
4 Brakes binding (Chapters 1 and 10).
5 Automatic transmission fluid level incorrect, causing slippage (Chapter 1).
6 Fuel filter clogged and/or impurities in the fuel system (Chapters 1 and 4).
7 EGR system not functioning properly (Chapter 6).
8 Use of sub-standard fuel. Fill tank with proper octane fuel.
9 Low or uneven cylinder compression pressures. Check as described in Chapter 2.
10 Vacuum leak at inlet manifold or vacuum hoses (check as described in Section 8).
11 Dirty or clogged fuel injector(s) (Chapters 1 and 4).
12 Fuel injection or engine control systems malfunction (Chapters 4 and 6).
13 Restricted exhaust system (Chapter 4).

18 Engine backfires

1 EGR system not functioning properly (Chapter 6).
2 Vacuum leak (refer to Section 8).
3 Damaged valve springs or sticking valves (Chapter 2).
4 Vacuum leak at the inlet manifold or vacuum hoses (see Section 8).
5 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

19 Engine surges while holding accelerator steady

1 Vacuum leak at the inlet manifold or vacuum hoses (see Section 8).
2 Fuel pump or pressure regulator defective (Chapter 4).
3 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

20 Pinging or knocking engine sounds when engine is under load

1 Incorrect ignition timing (V8 models).
2 Incorrect grade of fuel. Fill tank with fuel of the proper octane rating.
3 Incorrect spark plugs (Chapter 1).
4 Fuel injection or engine control systems malfunction (Chapters 4 and 6).

21 Engine diesels (continues to run) after being turned off

1 Idle speed too high (Chapter 4).
2 Incorrect ignition timing (V8 models).
3 Incorrect spark plug heat range (Chapter 1).
4 Vacuum leak at the inlet manifold or vacuum hoses (see Section 8).
5 EGR system not operating properly (Chapter 6).
6 Fuel injection or engine control systems malfunction (Chapters 4 and 6).
7 Check for causes of overheating (Section 27).

22 Low oil pressure

1 Improper grade of oil.
2 Oil pump worn or damaged (Chapter 2).
3 Engine overheating (refer to Section 27).
4 Clogged oil filter (Chapter 1).
5 Clogged oil strainer (Chapter 2).
6 Oil pressure gauge not working properly (Chapter 2).

23 Excessive oil consumption

1 Loose oil drain plug.
2 Loose bolts or damaged sump gasket (Chapter 2).
3 Loose bolts or damaged front cover gasket (Chapter 2).
4 Front or rear crankshaft oil seal leaking (Chapter 2).
5 Loose bolts or damaged valve cover gasket (Chapter 2).
6 Loose oil filter (Chapter 1).
7 Loose or damaged oil pressure switch (Chapter 2).
8 Pistons and cylinders excessively worn (Chapter 2).
9 Piston rings not fitted correctly on pistons (Chapter 2).
10 Worn or damaged piston rings (Chapter 2).
11 Inlet and/or exhaust valve oil seals worn or damaged (Chapter 2).
12 Worn valve stems or guides.
13 Worn or damaged valves/guides (Chapter 2).
14 Faulty or incorrect PCV valve allowing too much crankcase airflow.

24 Excessive fuel consumption

1 Dirty or clogged air filter element (Chapter 1).
2 Low tyre pressure or incorrect tyre size (Chapter 10).
3 Inspect for binding brakes.
4 Fuel leakage. Check all connections, lines and components in the fuel system (Chapter 4).
5 Dirty or clogged fuel injectors (Chapter 4).
6 Fuel injection or engine control systems malfunction (Chapters 4 and 6).
7 Thermostat stuck open or not refitted.
8 Improperly operating transmission.

25 Fuel odour

1 Fuel leakage. Check all connections, lines and components in the fuel system (Chapter 4).
2 Fuel tank overfilled. Fill only to automatic shut-off.
3 Charcoal canister filter in Evaporative Emissions Control system clogged (Chapter 1).
4 Vapour leaks from Evaporative Emissions Control system lines (Chapter 6).

26 Miscellaneous engine noises

1 A strong dull noise that becomes more rapid as the engine accelerates indicates worn or damaged crankshaft bearings or an unevenly worn crankshaft. To pinpoint the trouble spot, remove the spark plug wire from one plug at a time and crank the engine over. If the noise stops, the cylinder with the removed plug wire indicates the problem area. Renew the bearing and/or service or renew the crankshaft (Chapter 2).

2 A similar (yet slightly higher pitched) noise to the crankshaft knocking described in the previous paragraph, that becomes more rapid as the engine accelerates, indicates worn or damaged connecting rod bearings (Chapter 2). The procedure for locating the problem cylinder is the same as described in Paragraph 1.

3 An overlapping metallic noise that increases in intensity as the engine speed increases, yet diminishes as the engine warms up indicates abnormal piston and cylinder wear (Chapter 2). To locate the problem cylinder, use the procedure described in Paragraph 1.

4 A rapid clicking noise that becomes faster as the engine accelerates indicates a worn piston pin or piston pin hole. This sound will happen each time the piston hits the highest and lowest points in the stroke (Chapter 2). The procedure for locating the problem piston is described in Paragraph 1.

5 A metallic clicking noise coming from the water pump indicates worn or damaged water pump bearings or pump. Renew the water pump (Chapter 3).

6 A rapid tapping sound or clicking sound that becomes faster as the engine speed increases indicates "valve tapping." This can be identified by holding one end of a section of hose to your ear and placing the other end at different spots along the valve cover. The point where the sound is loudest indicates the problem valve. If the pushrod and rocker arm components are in good shape, you likely have a collapsed valve lifter. Changing the engine oil and adding a high viscosity oil treatment will sometimes cure a stuck lifter problem. If the problem persists, the lifters, pushrods and rocker arms must be removed for inspection (see Chapter 2).

7 A steady metallic rattling or rapping sound coming from the area of the timing chain cover indicates a worn, damaged or out-of-adjustment timing chain. Service or renew the chain and related components (Chapter 2).

Cooling system

27 Overheating

1 Insufficient coolant in system (Chapter 1).

2 Drivebelt defective or not adjusted properly (Chapter 1).

3 Radiator core blocked or radiator grille dirty and restricted (Chapter 3).

4 Thermostat faulty (Chapter 3).

5 Cooling fan not functioning properly (Chapter 3).

6 Radiator cap not maintaining proper pressure. Have cap pressure tested by service station or repair shop.

7 Defective water pump (Chapter 3).

8 Inaccurate temperature gauge (Chapter 12).

28 Overcooling

1 Thermostat faulty (Chapter 3).

2 Inaccurate temperature gauge (Chapter 12).

29 External coolant leakage

1 Deteriorated or damaged hoses. Loose clamps at hose connections (Chapter 1).

2 Water pump seals defective. If this is the case, water will drip from the weep hole in the water pump body (Chapter 3).

3 Leakage from radiator core or header tank. This will require the radiator to be professionally repaired (see Chapter 3 for removal procedures).

4 Leakage from the coolant expansion tank.

5 Engine drain plugs or water jacket freeze plugs leaking (see Chapters 1 and 2).

6 Leak from coolant temperature switch (Chapter 3).

7 Leak from damaged gaskets or small cracks (Chapter 2).

30 Internal coolant leakage

Note: *Internal coolant leaks can usually be detected by examining the oil. Check the dipstick and inside the rocker arm cover for water deposits and an oil consistency like that of a milkshake.*

1 Leaking cylinder head gasket. Have the system pressure tested or remove the cylinder head (Chapter 2) and inspect.

2 Cracked cylinder bore or cylinder head. Dismantle engine and inspect (Chapter 2).

3 Loose cylinder head bolts (tighten as described in Chapter 2).

31 Abnormal coolant loss

1 Overfilling system (Chapter 1).

2 Coolant boiling away due to overheating (see causes in Section 27).

3 Internal or external leakage (see Sections 29 and 30).

4 Faulty radiator cap. Have the cap pressure tested.

5 Cooling system being pressurized by engine compression. This could be due to a cracked head or block or leaking head gasket(s).

32 Poor coolant circulation

1 Inoperative water pump. A quick test is to pinch the top radiator hose closed with your hand while the engine is idling, then release it. You should feel a surge of coolant if the pump is working properly (Chapter 3).

2 Restriction in cooling system. Drain, flush and refill the system (Chapter 1). If necessary, remove the radiator (Chapter 3) and have it reverse flushed or professionally cleaned.

3 Loose water pump drivebelt (Chapter 1).

4 Thermostat sticking (Chapter 3).

5 Insufficient coolant (Chapter 1).

33 Corrosion

1 Excessive impurities in the water. Soft, clean water is recommended. Distilled or rainwater is satisfactory.
2 Insufficient antifreeze solution (refer to Chapter 1 for the proper ratio of water to antifreeze).
3 Infrequent flushing and draining of system. Regular flushing of the cooling system should be carried out at the specified intervals as described in (Chapter 1).

Automatic transmission

Note: Due to the complexity of the automatic transmission, it's difficult for the home mechanic to properly diagnose and service. For problems other than the following, the vehicle should be taken to a reputable mechanic.

34 Fluid leakage

1 Automatic transmission fluid is a deep red colour, and fluid leaks should not be confused with engine oil which can easily be blown by air flow to the transmission.
2 To pinpoint a leak, first remove all built-up dirt and grime from the transmission. Degreasing agents and/or steam cleaning will achieve this. With the underside clean, drive the vehicle at low speeds so the air flow will not blow the leak far from its source. Raise the vehicle and determine where the leak is located. Common areas of leakage are:

a) ***Fluid pan:*** *tighten mounting bolts and/or renew pan gasket as necessary (Chapter 1).*
b) ***Rear extension:*** *tighten bolts and/or renew oil seal as necessary.*
c) ***Filler pipe:*** *renew the rubber oil seal where pipe enters transmission case.*
d) ***Transmission oil lines:*** *tighten fittings where lines enter transmission case and/or renew lines.*
e) ***Vent pipe:*** *transmission overfilled and/or water in fluid (see checking procedures, Chapter 1).*
f) ***Speed sensor:*** *renew the O-ring where vehicle speed sensor enters transmission case.*

35 General shift mechanism problems

Chapter 7 deals with checking and adjusting the shift linkage on automatic transmissions. Common problems which may be caused by out of adjustment linkage are:

a) *Engine starting in gears other than P (park) or N (Neutral).*
b) *Indicator pointing to a gear other than the one actually engaged.*
c) *Vehicle moves with transmission in P (Park) position.*

36 Transmission will not downshift with the accelerator pedal pressed to the floor

This problem can be caused by an internal fault or a malfunction in the transmission electronic controls. See your dealer.

37 Engine will start in gears other than Park or Neutral

Chapter 7 deals with adjusting the Neutral start switch refitted on automatic transmissions.

38 Transmission slips, shifts roughly, is noisy or has no drive in forward or Reverse gears

1 There are many probable causes for the above problems, but the home mechanic should concern himself only with one possibility; fluid level.
2 Before taking the vehicle to a shop, check the fluid level and condition as described in Chapter 1. Add fluid, if necessary, or change the fluid and filter if needed. If problems persist, have a professional diagnose the transmission.

Driveshaft

Note: Refer to Chapter 8, unless otherwise specified, for service information.

39 Leaks at front of driveshaft

Defective transmission or transfer case seal. See Chapter 7 for renewal procedure. As this is done, check the splined yoke for burrs or roughness that could damage the new seal. Remove burrs with a fine file or whetstone.

40 Knock or clunk when transmission is under initial load (just after transmission is put into gear)

1 Loose or disconnected rear suspension components. Check all mounting bolts and bushes (Chapters 7 and 10).
2 Loose driveshaft bolts. Inspect all bolts and nuts and tighten them securely.
3 Worn or damaged universal joint bearings (Chapter 8).
4 Worn sleeve yoke and mainshaft spline.

41 Metallic grating sound consistent with vehicle speed

Pronounced wear in the universal joint bearings. Renew U-joints or driveshaft, as necessary.

42 Vibration

Note: Before blaming the driveshaft, make sure the tyres are perfectly balanced and perform the following test.

1 Connect a tachometer inside the vehicle to monitor engine speed as the vehicle is driven. Drive the vehicle and note the engine speed at which the vibration (roughness) is most

pronounced. Now shift the transmission to a different gear and bring the engine speed to the same point.

2 If the vibration occurs at the same engine speed (rpm) regardless of which gear the transmission is in, the driveshaft is NOT at fault since the driveshaft speed varies.

3 If the vibration decreases or is eliminated when the transmission is in a different gear at the same engine speed, refer to the following probable causes:

a) Bent or dented driveshaft. Inspect and renew as necessary.
b) Undercoating or built-up dirt, etc. on the driveshaft. Clean the shaft thoroughly.
c) Worn universal joint bearings. Renew the U-joints or driveshaft as necessary.
d) Driveshaft and/or companion flange out of balance. Check for missing weights on the shaft. Remove driveshaft and reinstall 180-degrees from original position, then recheck. Have the driveshaft balanced if problem persists.
e) Loose driveshaft mounting bolts/nuts.
f) Worn transmission rear bush (Chapter 7).

43 Scraping noise

Make sure there is nothing, such as an exhaust heat shield, rubbing on the driveshaft.

Axle(s) and differential(s)

***Note:** For differential servicing information, refer to Chapter 8, unless otherwise specified.*

44 Noise - same when in drive as when vehicle is coasting

1 Road noise. No corrective action available.
2 Tyre noise. Inspect tyres and check tyre pressures (Chapter 1).
3 Front wheel bearings loose, worn or damaged (Chapter 1).
4 Insufficient differential oil (Chapter 1).
5 Defective differential.

45 Knocking sound when starting or shifting gears

Defective or incorrectly adjusted differential.

46 Noise when turning

Defective differential.

47 Vibration

See probable causes under Driveshaft. Proceed under the guidelines listed for the driveshaft. If the problem persists, check the rear wheel bearings by raising the rear of the vehicle and spinning the wheels by hand. Listen for evidence of rough (noisy) bearings. Remove and inspect (Chapter 8).

48 Oil leaks

1 Pinion oil seal damaged (Chapter 8).
2 Axleshaft oil seals damaged (Chapter 8).
3 Differential cover leaking. Tighten mounting bolts or renew the gasket as required.
4 Loose filler plug on differential (Chapter 1).
5 Clogged or damaged breather on differential.

Brakes

***Note:** Before assuming a brake problem exists, make sure the tyres are in good condition and inflated properly, the front end alignment is correct and the vehicle is not loaded with weight in an unequal manner. All service procedures for the brakes are included in Chapter 9, unless otherwise noted.*

49 Vehicle pulls to one side during braking

1 Defective, damaged or oil contaminated brake pad or lining on one side. Inspect as described in Chapter 1. Refer to Chapter 9 if renewal is required.
2 Excessive wear of brake pad or lining material, disc or drum on one side. Inspect and repair as necessary.
3 Loose or disconnected front suspension components. Inspect and tighten all bolts securely (Chapters 1 and 10).
4 Defective front brake caliper assembly. Remove caliper and inspect for stuck piston or damage.
5 Brake lining adjustment needed. Inspect automatic adjusting mechanism for proper operation.
6 Scored or out of round disc or drum.
7 Loose front brake caliper mounting bolts.
8 Incorrect wheel bearing adjustment.

50 Noise (high-pitched squeal)

1 Front brake pads worn out. This noise comes from the wear sensor rubbing against the disc. Renew pads immediately!
2 Glazed or contaminated pads.
3 Dirty or scored rotor.
4 Bent support plate.

51 Excessive brake pedal travel

1 Partial brake system failure. Inspect entire system (Chapter 1) and correct as required.
2 Insufficient fluid in master cylinder. Check (Chapter 1) and add fluid - bleed system if necessary.
3 Air in system. Bleed system.
4 Excessive lateral rotor play.
5 Brakes out of adjustment. Check the operation of the automatic adjusters.
6 Defective proportioning valve. Renew valve and bleed system.
7 Defective master cylinder.

52 Brake pedal feels spongy when depressed

1 Air in brake lines. Bleed the brake system.
2 Deteriorated rubber brake hoses. Inspect all system hoses and lines. Renew parts as necessary.
3 Master cylinder mounting nuts loose. Inspect master cylinder bolts (nuts) and tighten them securely.
4 Master cylinder faulty.
5 Incorrect shoe or pad clearance.
6 Defective check valve. Renew valve and bleed system.
7 Clogged reservoir cap vent hole.
8 Deformed rubber brake lines.
9 Soft or swollen caliper seals.
10 Poor quality brake fluid. Bleed entire system and fill with new approved fluid.

53 Excessive effort required to stop vehicle

1 Power brake booster not operating properly.
2 Excessively worn linings or pads. Check and renew if necessary.
3 One or more caliper pistons seized or sticking. Inspect and rebuild as required.
4 Brake pads or linings contaminated with oil or grease. Inspect and renew as required.
5 Worn or damaged master cylinder or caliper assemblies. Check particularly for seized pistons.

54 Pedal travels to the floor with little resistance

Little or no fluid in the master cylinder reservoir caused by leaking caliper piston(s) or loose, damaged or disconnected brake lines. Inspect entire system and repair as necessary.

55 Brake pedal pulsates during brake application

Rotors not within specifications. Remove the rotors and check for excessive lateral runout and parallelism. Have the rotors resurfaced or renew them.

56 Brakes drag (indicated by sluggish engine performance or wheels being very hot after driving)

1 Pushrod adjustment incorrect at the brake pedal or power booster.
2 Obstructed master cylinder compensator. Disassemble master cylinder and clean.
3 Master cylinder piston seized in bore. Overhaul master cylinder.
4 Caliper assembly in need of overhaul.
5 Brake pads worn out.
6 Piston cups in master cylinder or caliper assembly deformed. Overhaul master cylinder.
7 Rotor not within specifications.
8 Parking brake assembly will not release.
9 Clogged brake lines.
10 Brake pedal height improperly adjusted.

57 Rear brakes lock up under light brake application

1 Tyre pressures too high.
2 Tyres excessively worn (Chapter 1).

58 Rear brakes lock up under heavy brake application

1 Tyre pressures too high.
2 Tyres excessively worn (Chapter 1).
3 Front brake pads contaminated with oil, mud or water. Clean or renew the pads.
4 Front brake pads excessively worn.
5 Defective master cylinder or caliper assembly.

59 Extremely hard pedal feel

1 Malfunctioning power brake booster.
2 Defective pedal linkage.

Suspension and steering

***Note:** All service procedures for the suspension and steering systems are included in Chapter 10, unless otherwise noted.*

60 Vehicle pulls to one side

1 Tyre pressures uneven (Chapter 1).
2 Defective tyre (Chapter 1).
3 Excessive wear in suspension or steering components (Chapter 1).
4 Front end alignment incorrect.
5 Front brakes dragging. Inspect as described in Section 71.
6 Wheel lug nuts loose.

61 Shimmy, shake or vibration

1 Tyre or wheel out of balance or out of round.
2 Loose or worn wheel bearings (Chapter 10).
3 Shock absorbers and/or suspension components worn or damaged (see Chapter 10).

62 Excessive pitching and/or rolling around corners or during braking

1 Defective shock absorbers. Renew as a set.
2 Loose or worn wheel bearings (Chapter 10).
3 Broken or weak springs and/or suspension components.
4 Worn or damaged stabiliser bar or bushes.

63 Wandering or general instability

1 Improper tyre pressures.
2 Incorrect front end alignment.
3 Worn or damaged steering linkage or suspension components.
4 Improperly adjusted steering gear.
5 Out-of-balance wheels.
6 Loose wheel lug nuts.
7 Worn rear shock absorbers.
8 Loose or worn wheel bearings (Chapter 10).

64 Excessively stiff steering

1 Lack of fluid in the power steering fluid reservoir, where appropriate (Chapter 1).
2 Incorrect tyre pressures (Chapter 1).
3 Lack of lubrication at balljoints (Chapter 1).
4 Steering gear out of adjustment or lacking lubrication.
5 Worn or damaged steering gear.
6 Low tyre pressures.
7 Worn or damaged balljoints.
8 Worn or damaged steering linkage.

65 Excessive play in steering

1 Worn steering linkage.
2 Steering gear mounting bolts loose.
3 Steering gear improperly adjusted.
4 Loose or worn wheel bearings (Chapter 10).

66 Lack of power assistance

1 Steering pump drivebelt faulty or not adjusted properly (Chapter 1).
2 Fluid level low (Chapter 1).
3 Hoses or pipes restricting the flow. Inspect and renew parts as necessary.
4 Air in power steering system. Bleed system.
5 Defective power steering pump.

67 Steering wheel fails to return to straight-ahead position

1 Incorrect front end alignment.
2 Tyre pressures low.
3 Steering gears improperly engaged.
4 Steering column out of alignment.
5 Worn or damaged balljoint.
6 Worn or damaged steering linkage.
7 Insufficient oil in steering gear.
8 Lack of fluid in power steering pump.

68 Steering effort not the same in both directions (power system)

1 Leaks in steering gear.
2 Clogged fluid passage in steering gear.

69 Noisy power steering pump

1 Insufficient oil in pump.
2 Clogged hoses or oil filter in pump.
3 Loose pulley.
4 Improperly adjusted drivebelt (Chapter 1).
5 Defective pump.

70 Miscellaneous noises

1 Improper tyre pressures.
2 Insufficiently lubricated balljoint or steering linkage.
3 Loose or worn steering gear, steering linkage or suspension components.
4 Defective shock absorber.
5 Defective wheel bearing.
6 Worn or damaged suspension bushes.
7 Defective spring.
8 Loose wheel lug nuts.
9 Worn or damaged rear axleshaft spline.
10 Worn or damaged rear shock absorber mounting bush.
11 Incorrect rear axle endplay.
12 See also causes of noises at the rear axle and driveshaft.

71 Excessive tyre wear (not specific to one area)

1 Incorrect tyre pressures.
2 Tyres out of balance.
3 Wheels damaged. Inspect and renew as necessary.
4 Suspension or steering components worn (Chapter 1).
5 Front end alignment incorrect.
6 Lack of proper tyre rotation routine. See Routine Maintenance Schedule, Chapter 1.

72 Excessive tyre wear on outside edge

1 Incorrect tyre pressure.
2 Excessive speed in turns.
3 Front end alignment incorrect.

73 Excessive tyre wear on inside edge

1 Incorrect tyre pressure.
2 Front end alignment incorrect.
3 Loose or damaged steering components (Chapter 1).

74 Tyre tread worn in one place

1 Tyres out of balance.
2 Damaged or buckled wheel. Inspect and renew if necessary.
3 Defective tyre.

Notes

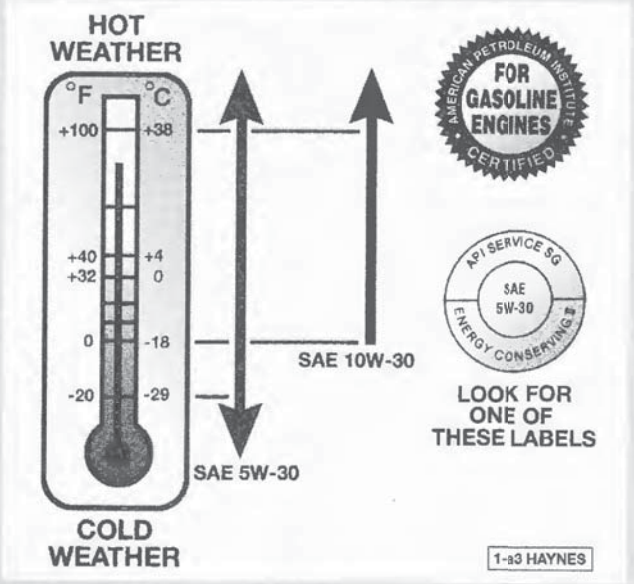
Chapter 1
Tune-up and routine maintenance

Contents

Specifications

Recommended lubricants and fluids

Engine oil	
Type	
VT to VY models	API grade SF, SG, SH or SJ multigrade and fuel-efficient oil
VZ model	API grade SL or SM ILSAC GF3 or GF4
Viscosity	See accompanying chart



Engine oil viscosity chart - For best fuel economy and cold starting, select the lowest SAE viscosity grade for the expected temperature range

Manual transmission lubricant	
3.8 Litre V6 and 5.0 Litre V8	80W gear oil
3.6 Litre V6	75W/90 GL5
5.7 Litre and 6.0 Litre V8	DEXRON III Automatic Transmission Fluid (ATF)
Automatic transmission fluid	
4-speed	DEXRON III Automatic Transmission Fluid (ATF)
5-speed	DEXRON VI Automatic Transmission Fluid (ATF)
Engine coolant	A 50/50 mixture of water and inhibited ethylene glycol-based antifreeze
Brake fluid	DOT 4 brake fluid
Clutch fluid	DOT 4 brake fluid
Manual steering lubricant	EP semi fluid base type O grease
Power steering fluid	DEXRON III Automatic Transmission Fluid (ATF)
Supercharger	Synthetic oil GM #12345982
Differential	
V6, standard models	SAE 90W gear oil
V8, utility, supercharged and limited slip V6 models	SAE 80W/140 synthetic gear oil

Capacities*

Engine oil (with filter change)	
3.8 Litre V6	4.3 to 5.6 litres
3.6 Litre V6	6.5 litres
V8	5.1 to 6.2 litres
Cooling system**	10 to 14 litres
Manual transmission	
Except 5.7 Litre and 6.0 Litre V8	Up to 2.0 litres
5.7 Litre and 6.0 Litre V8	Up to 4.4 litres
Automatic transmission	
Fluid and filter renewal	
V6	4.8 litres
V8	5.0 litres
Total refill capacity from dry (including torque converter)	
3.8 Litre V6	7.9 litres
3.6 Litre V6	8.8 litres
5.0 Litre V8	12.0 litres
5.7 Litre and 6.0 Litre V8	10.5 litres
Differential	1.7 litres
Power steering	
V6 models	0.70 litres
V8 models	0.65 litres

** All capacities approximate. Add as necessary to bring to appropriate level.*

*** On 3.8 Litre V6 and 5.0 Litre V8, Holden recommends the addition of cooling system pellets (M40124) whenever the system is drained. One pellet for every four litres drained.*

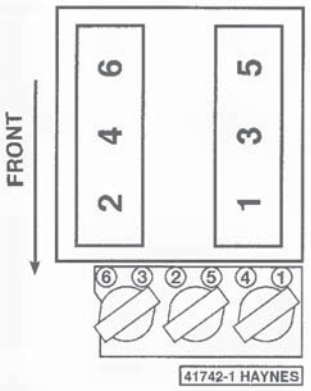
General

Radiator cap pressure rating	
V6 models	
3.8 Litre	135 kPa
3.6 Litre	120 kPa
V8 models	
VT and VX	100 kPa
VY Generation III	103 kPa
VZ Generation III and Generation IV	120 kPa
Brake pad wear limit	3 mm
Parking brake lever engagement	4 to 6 clicks

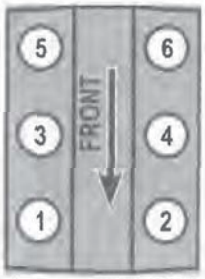
Ignition system

Firing order	
V6 engine	
3.8 Litre	1-6-5-4-3-2
3.6 Litre	1-2-3-4-5-6
V8 engine	
5.0 Litre	1-2-7-8-4-5-6-3
5.7 Litre and 6.0 Litre	1-8-7-2-6-5-4-3

Spark plug type	
3.8 Litre V6 non-supercharged	
1997 and 1998 models	BPR6EFS or AC R42LTS6
1999 and later models	BPR6EFS-15
3.8 Litre V6 supercharged	
1997 and 1998 models	AC 41-919
1999 and later models	BPR6EFS-13
3.6 Litre V6	Bosch HR7MPP302X, NGK LTR6AP-11
5.0 Litre V8	AC R42LTS
5.7 Litre and 6.0 Litre V8	AC 41-952
Spark plug gap	
3.8 Litre V6	
Except 1999 and later V6 supercharged engines	1.5 to 1.6 mm
1999 and later V6 supercharged engines	1.2 to 1.3 mm
3.6 Litre V6	1.1 to 1.2 mm
5.0 Litre V8	1.0 mm
5.7 Litre and 6.0 Litre V8	1.5 mm
Ignition timing, in diagnostic mode	
V6	10-degrees BTDC, not adjustable
5.0 Litre V8 engine	10-degrees BTDC
Idle speed in neutral, engine warm	
V6, non-supercharged	
3.8 Litre manual transmission and 3.6 Litre	725 to 825 RPM
3.8 Litre automatic transmission	675 to 775 RPM
V6, supercharged	750 to 850 RPM
V8 engines	
5.0 Litre	600 to 800 RPM
5.7 Litre and 6.0 Litre	600 to 700 RPM



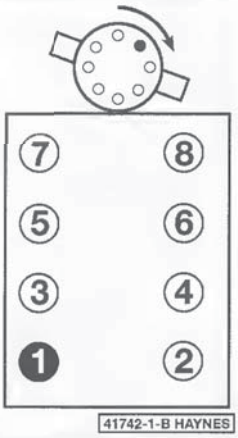
3.8 litre V6 engine cylinder and spark plug wire terminal locations



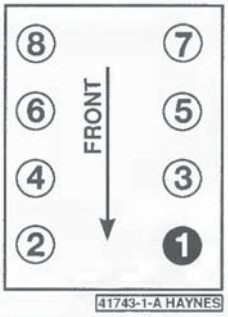
VZ V6-cylinder locations

Torque specifications	**Nm**
Spark plugs	
3.8 Litre V6	15 to 25
3.6 Litre V6	16 to 20
5.0 Litre V8	20
5.7 Litre and 6.0 Litre V8	25
Engine oil drain plug	
3.8 Litre V6 and 5.0 Litre V8	30 to 60
3.6 Litre V6, 5.7 Litre and 6.0 Litre V8	25
3.6 Litre V6 oil filter adapter cap	25
Manual transmission drain plug	
3.8 Litre V6	40 to 60
3.6 Litre V6	37
5.0 Litre V8	40 to 60
5.7 Litre V8	20 to 34
6.0 Litre V8	28
Manual transmission filler plug	
3.8 Litre V6	40 to 60
3.6 Litre V6	37
5.0 Litre V8	25
5.7 Litre V8	15 to 25
6.0 Litre V8	28
Automatic transmission pan bolts	9.5 to 13.8
5 speed automatic transmission filler and drain plugs	20
Wheel lug nuts	110 to 140
Supercharger fill plug	10
Engine block coolant drain plugs	
3.8 Litre V6	19
5.7 Litre and 6.0 Litre V8	60
Throttle body bolts	
V6	
3.8 Litre	15 to 20
3.6 Litre	8 to 12
5.0 Litre V8	
Nuts	12 to 16
Studs	12 to 20
5.7 Litre and 6.0 Litre V8	12

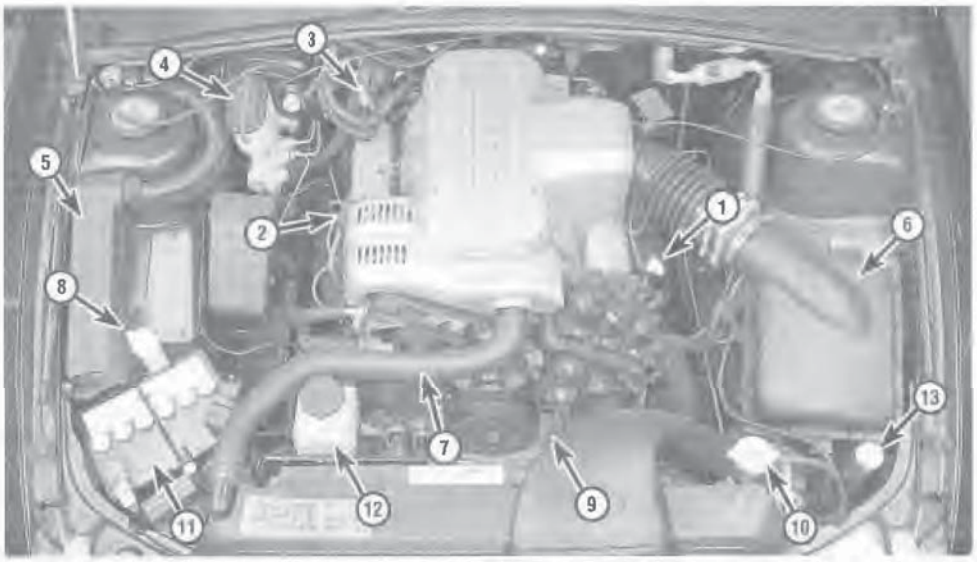
The blackened terminal shown on the distributor cap indicates the Number One spark plug wire position



5.0 litre V8 engine cylinder and spark plug wire terminal locations

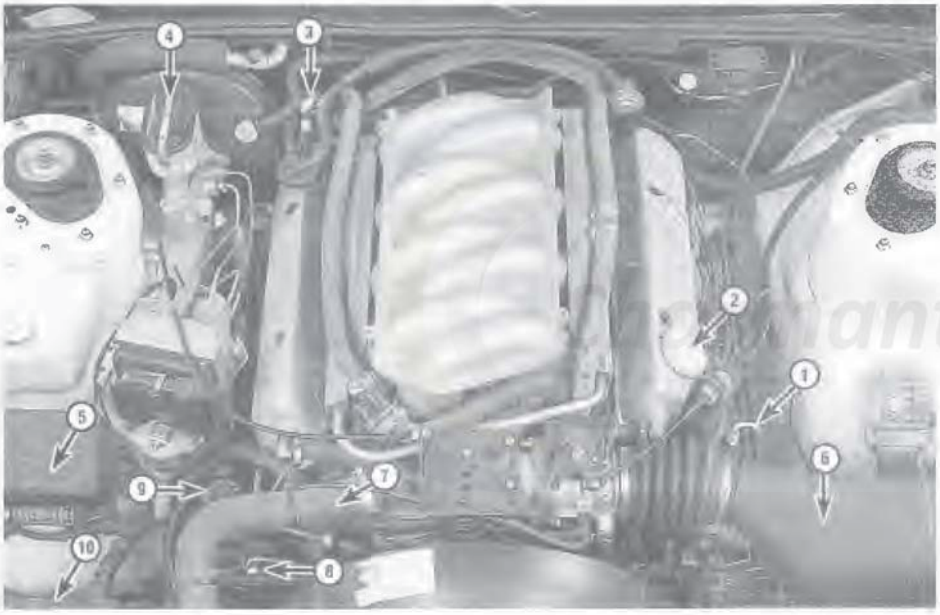


5.7 litre Generation III and 6.0 litre Generation IV V8 engine cylinder locations



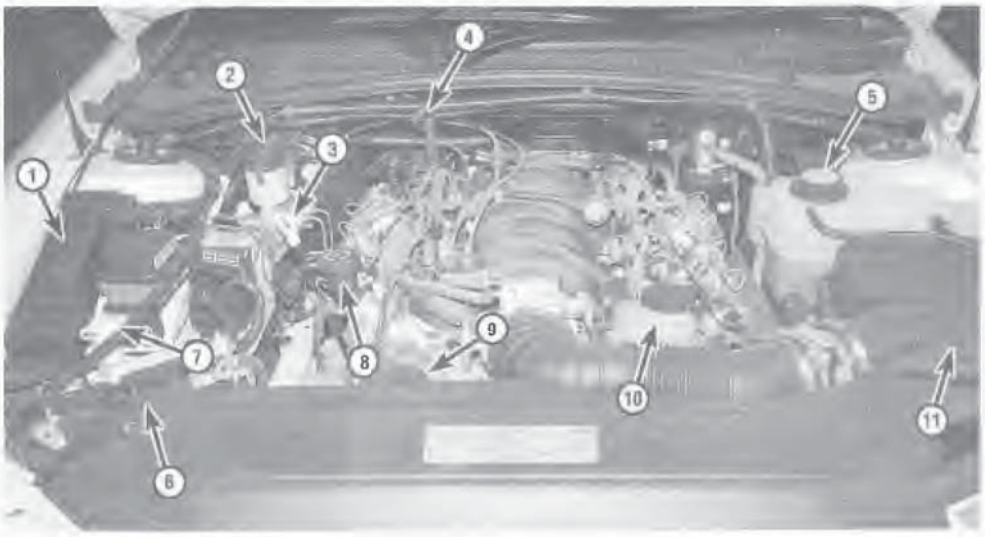
Typical V6 engine compartment layout

1 *Engine oil dipstick*
2 *Engine oil filler cap*
3 *Automatic transmission dipstick*
4 *Brake master cylinder reservoir*
5 *Fuse and electrical centre*
6 *Air filter housing*
7 *Upper radiator hose*
8 *Windscreen washer reservoir*
9 *Drivebelt*
10 *Radiator cap*
11 *Battery*
12 *Power steering fluid reservoir*
13 *Engine coolant reservoir*



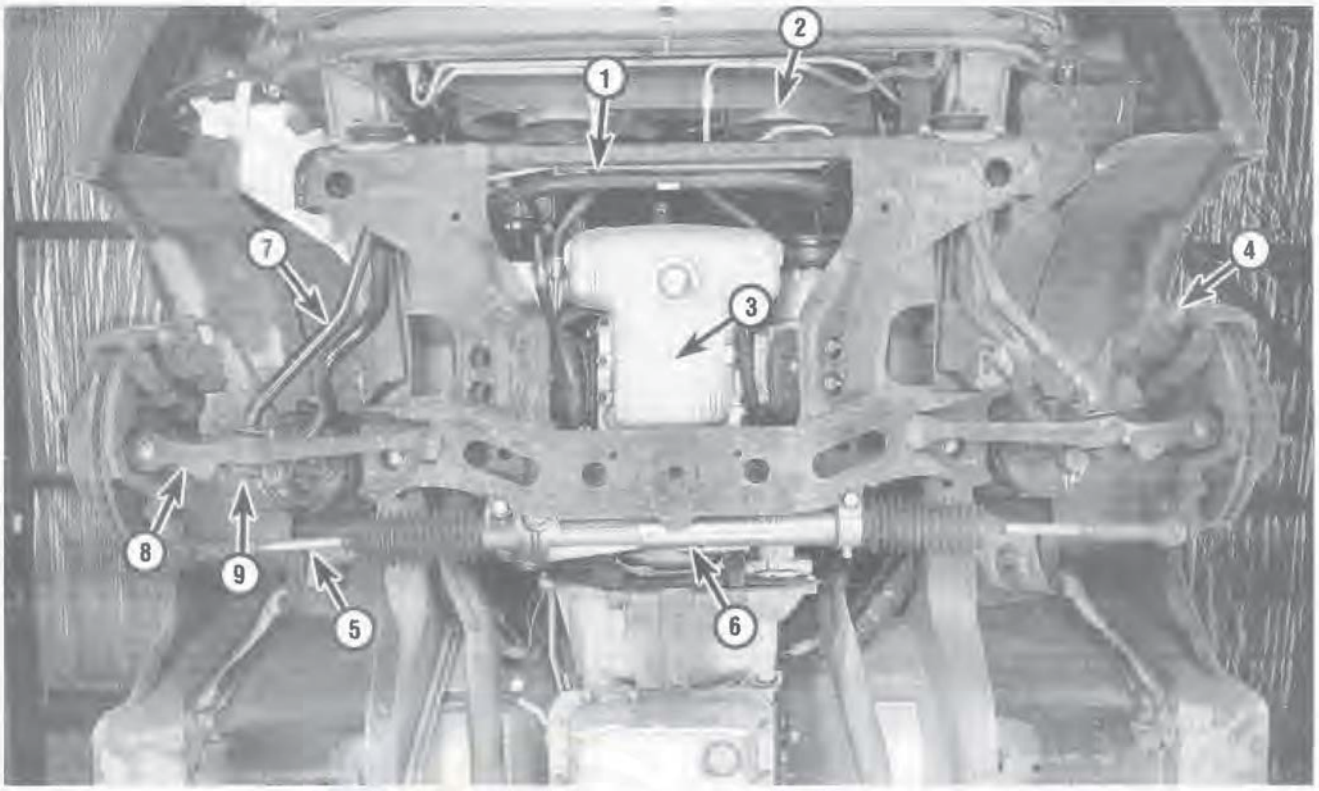
Typical 5.0 litre V8 engine compartment layout

1 *Engine oil dipstick*
2 *Engine oil filler cap*
3 *Automatic transmission dipstick*
4 *Brake master cylinder reservoir*
5 *Fuse and electrical centre*
6 *Air filter housing*
7 *Upper radiator hose*
8 *Drivebelt*
9 *Power steering fluid reservoir*
10 *Battery*



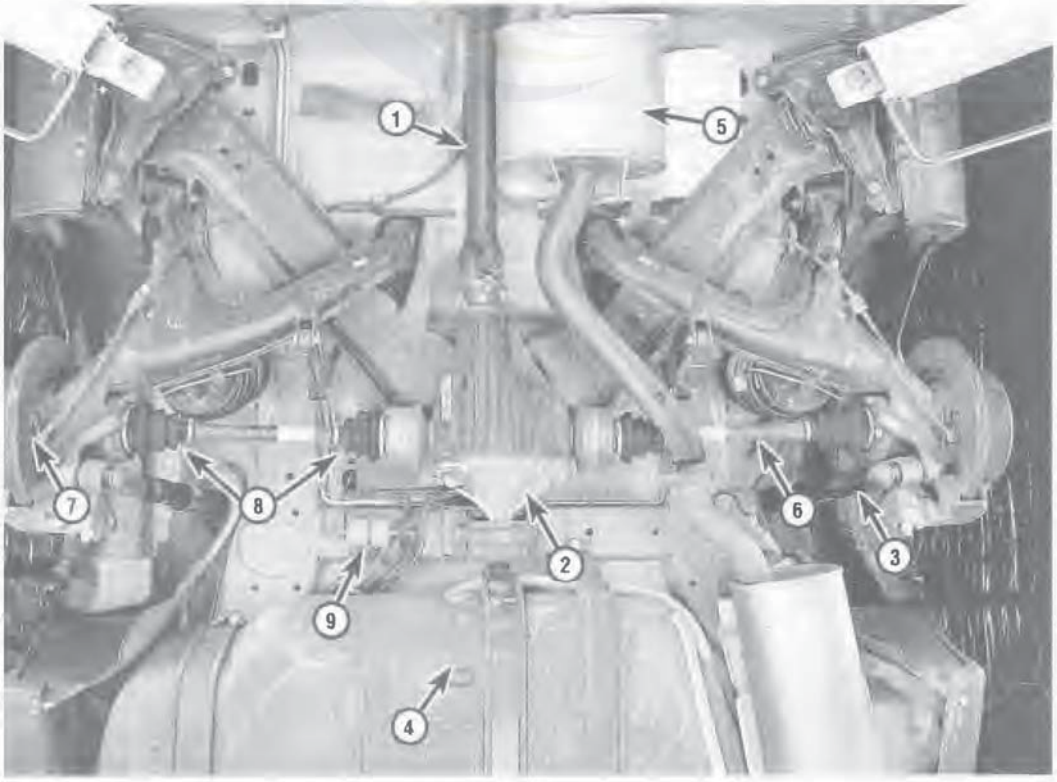
Typical 5.7 litre Generation III V8 engine compartment layout

1 *Fuse and electrical centre*
2 *Brake master cylinder reservoir*
3 *Engine oil dipstick*
4 *Automatic transmission dipstick*
5 *Radiator cap and surge tank*
6 *Battery*
7 *Windscreen fluid reservoir*
8 *Engine oil filler cap*
9 *Drivebelt*
10 *Power steering fluid reservoir*
11 *Air filter housing*



Typical front underside components

1 *Stabiliser bar*
2 *Cooling fan*
3 *Sump*
4 *Brake caliper*
5 *Tie rod*
6 *Steering rack and pinion*
7 *Tension rod*
8 *Lower control arm*
9 *Tension rod damper*



Typical rear underside components

1 *Driveshaft*
2 *Final drive unit*
3 *Shock absorber*
4 *Fuel tank*
5 *Muffler*
6 *Axle*
7 *Rear brake*
8 *Constant velocity joints*
9 *Fuel filter*

1 Holden Maintenance schedule

The following maintenance intervals are based on the assumption that the vehicle owner will be doing the maintenance or service work, as opposed to having a dealer service department do the work. Although the time/distance intervals are loosely based on factory recommendations, most have been shortened to ensure, for example, that such items as lubricants and fluids are checked/changed at intervals that promote maximum engine/driveline service life. Also, subject to the preference of the individual owner interested in keeping his or her vehicle in peak condition at all times, and with the vehicle's ultimate resale in mind, many of the maintenance procedures may be performed more often than recommended in the following schedule. We encourage such owner initiative.

When the vehicle is new it should be serviced initially by a factory authorised dealer service department to protect the factory warranty. In many cases the initial maintenance check is done at no cost to the owner (check with your dealer service department for more information).

EVERY 400 KILOMETRES OR WEEKLY, WHICHEVER COMES FIRST

Check the engine oil level (Section 4)
Check the engine coolant level (Section 4)
Check the windscreen washer fluid level (Section 4)
Check the brake fluid level (Section 4)
Check the tyres and tyre pressures (Section 5)

EVERY 5000 KILOMETRES OR 3 MONTHS, WHICHEVER COMES FIRST

All items listed above plus:

Check the automatic transmission fluid level (Section 6)
Check the power steering fluid level (Section 7)
Change the engine oil and filter (Section 8)
Check and service the battery (Section 9)

EVERY 12,000 KILOMETRES OR 6 MONTHS, WHICHEVER COMES FIRST

All items listed above plus:

Check the cooling system (Section 10)
Inspect and renew, if necessary, all underbonnet hoses (Section 11)
Inspect and renew, if necessary, the windscreen wiper blades (Section 12)
Inspect the suspension and steering components (Section 13)
Inspect the exhaust system (Section 14)
Inspect the seatbelts (Section 15)
Check the starter safety switch (Section 16)

EVERY 24,000 KILOMETRES OR 12 MONTHS, WHICHEVER COMES FIRST

Check the manual transmission lubricant level (Section 17)
Check the differential lubricant level (Section 18)
Rotate the tyres (Section 19)
Check the brakes (Section 20)
Inspect the fuel system (Section 21)

EVERY 48,000 KILOMETRES OR 24 MONTHS, WHICHEVER COMES FIRST

All items listed above plus:

Check the supercharger oil level (Section 22)
Renew the air filter (Section 23)
Renew the fuel filter (Section 24)
Check the engine drivebelts (Section 25)
Change the automatic transmission fluid and filter (Section 26)
Change the manual transmission lubricant (Section 27)
Change the differential lubricant (Section 28)
Service the cooling system (drain, flush and refill) (Section 29)
Check and adjust, if necessary, the engine ignition timing (V8 engine) (Section 30)
Inspect and renew, if necessary, the PCV valve (Section 31)
Inspect the evaporative emissions control system (Section 32)
Renew the spark plugs (Section 33)
Inspect the spark plug wires (Section 34)
Clean the throttle body and check the mounting nut torque (Section 35)

** If the vehicle frequently tows a trailer, is operated primarily in stop-and-go conditions or its brakes receive severe usage for any other reason, check the brakes every 5000 kilometres or three months.*

*** If operated under one or more of the following conditions, change the automatic transmission fluid every 24,000 kilometres:*

In heavy city traffic where the outside temperature regularly reaches 32 degrees C or higher
In hilly or mountainous terrain
Frequent trailer pulling

2 Introduction

This Chapter is designed to help the home mechanic maintain the Holden Commodore VT to VZ models with the goals of maximum performance, economy, safety and reliability in mind.

Included is a master maintenance schedule, followed by procedures dealing specifically with each item on the schedule. Visual checks, adjustments, component renewal and other helpful items are included. Refer to the accompanying illustrations of the engine compartment and the underside of the vehicle for the locations of various components.

Servicing your vehicle in accordance with the distance/time maintenance schedule and the step-by-step procedures will result in a planned maintenance program that should produce a long and reliable service life. Keep in mind that it's a comprehensive plan, so maintaining some items but not others at the specified intervals will not produce the same results.

As you service your vehicle, you'll discover that many of the procedures can - and should - be grouped together because of the nature of the particular procedure you're performing or because of the close proximity of two otherwise unrelated components to one another.

For example, if the vehicle is raised, you should inspect the exhaust, suspension, steering and fuel systems while you're under the vehicle. When you're rotating the tyres, it makes good sense to check the brakes since the wheels are already removed. Finally, let's suppose you have to borrow or rent a torque wrench. Even if you only need it to tighten the spark plugs, you might as well check the torque of as many critical fasteners as time allows.

The first step in this maintenance program is to prepare yourself before the actual work begins. Read through all the procedures you're planning to do, then gather up all the parts and tools needed. If it looks like you might run into problems during a particular job, seek advice from a mechanic or an experienced do-it-yourselfer.

3 Tune-up general information

The term "tune-up" is used in this manual to represent a combination of individual operations rather than one specific procedure.

If, from the time the vehicle is new, the routine maintenance schedule is followed closely and frequent checks are made of fluid levels and high wear items, as suggested throughout this manual, the engine will be kept in relatively good running condition and the need for additional work will be minimised. This is even more likely if a used vehicle, which has not received regular and frequent maintenance checks, is purchased. In such cases, an engine tune-up will be needed outside of the regular routine maintenance intervals.

The first step in any tune-up or diagnostic procedure to help correct a poor running engine is a cylinder compression check. A compression check (see Chapter 2A) will help determine the condition of internal engine components and should be used as a guide for tune-up and repair procedures. If, for instance, a compression check indicates serious internal engine wear, a conventional tune-up won't improve the performance of the engine and would be a waste of time and money. Because of its importance, the compression check should be done by someone with the right equipment and the knowledge to use it properly.

The following procedures are those most often needed to bring a generally poor running engine back into a proper state of tune.

MINOR TUNE-UP

Check all engine related fluids (Section 4)
Clean, inspect and test the battery (Section 9)
Check the cooling system (Section 10)
Check all underbonnet hoses (Section 11)
Check the air filter (Section 23)
Check and adjust the drivebelts (Section 25)
Check the PCV valve (Section 31)
Renew the spark plugs (Section 33)
Inspect the spark plug wires (Section 34)

MAJOR TUNE-UP

All items listed under Minor tune-up plus ...

Check the fuel system (Section 23)
Renew the air filter (Section 24)
Renew the fuel filter Section 25)
Check the ignition timing (5.0 litre V8 models) (Section 30)
Renew the spark plug wires (Section 34)
Check the charging system (Chapter 5)

4 Fluid level checks (every 400 kilometres or weekly)

Note: *The following are fluid level checks to be done on a 400 kilometre or weekly basis. Additional fluid level checks can be found in specific maintenance procedures which follow. Regardless of intervals, be alert to fluid leaks under the vehicle which would indicate a problem to be corrected immediately.*

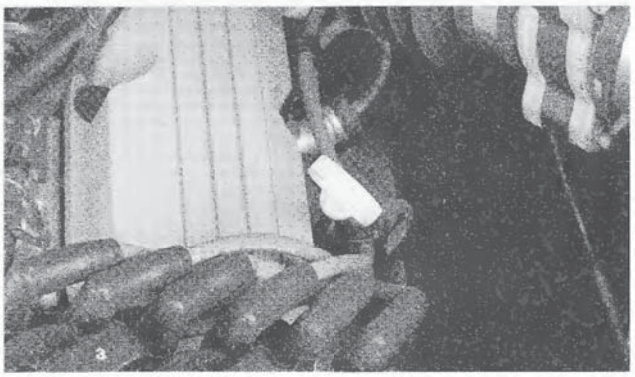
1 Fluids are an essential part of the lubrication, cooling, brake and windscreen washer systems. Because the fluids gradually become depleted and/or contaminated during normal operation of the vehicle, they must be periodically replenished. See *Recommended lubricants and fluids* at the beginning of this Chapter before adding fluid to any of the following components.

Note: *The vehicle must be on level ground when fluid levels are checked.*

ENGINE OIL

Refer to illustrations 4.2, 4.4 and 4.6

2 The engine oil level is checked with a dipstick (see illustration). The dipstick extends through a metal tube down into the sump.



4.2 The engine oil dipstick is mounted prominently on the side of the engine

4.4 The oil level should be at or near the upper mark on the dipstick - if it's below the ADD line, add enough oil to bring the level into the upper mark

3 The oil level should be checked before the vehicle has been driven, or a few minutes after the engine has been shut off. If the oil is checked immediately after driving the vehicle, some of the oil will remain in the upper part of the engine, resulting in an inaccurate reading on the dipstick.

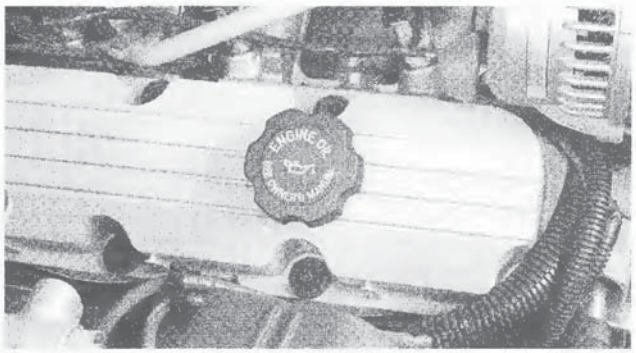
4 Pull the dipstick from the tube and wipe all the oil from the end with a clean rag or paper towel. Insert the clean dipstick all the way back into the tube and pull it out again. Note the oil at the end of the dipstick. Add oil as necessary to keep the level above the ADD mark of the dipstick (see illustration).

5 Do not overfill the engine by adding too much oil since this may result in oil fouled spark plugs, oil leaks or oil seal failures.

6 Oil is added to the engine after removing a cap located on the engine (see illustration). A funnel may help to reduce spills.

7 Checking the oil level is an important preventive maintenance step. A consistently low oil level indicates oil leakage through damaged seals, defective gaskets or past worn rings or valve guides. If the oil looks milky in colour or has water droplets in it, the cylinder head gasket may be blown or the head or block may be cracked. The engine should be checked immediately. The condition of the oil should also be checked. Whenever you check the oil level, slide your thumb and index finger up the dipstick before wiping off the oil. If you see small dirt or metal particles clinging to the dipstick, the oil should be changed (see Section 8).

4.9a DO NOT remove the radiator cap unless the engine has thoroughly cooled



4.6 The engine oil filler cap is clearly marked and screws into the valve cover

ENGINE COOLANT

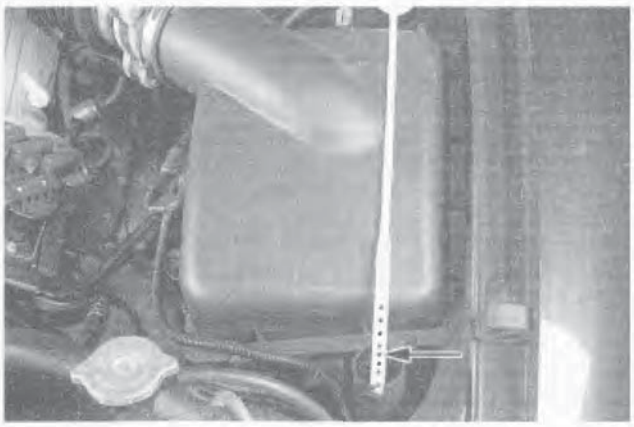
Refer to illustrations 4.9a and 4.9b

***Warning:** Do not allow antifreeze to come in contact with your skin or painted surfaces of the vehicle. Flush contaminated areas immediately with plenty of water. Do not store new coolant or leave old coolant lying around where it's accessible to children or pets - they're attracted by its sweet smell. Ingestion of even a small amount of coolant can be fatal! Wipe up garage floor and drip pan coolant spills immediately. Keep antifreeze containers covered and repair leaks in the cooling system immediately.*

8 All vehicles covered by this manual are equipped with a pressurised coolant recovery system. A plastic coolant reservoir is connected by a hose to the radiator filler neck. As the engine warms up and the coolant expands, it escapes through a valve in the radiator cap and travels through the hose into the reservoir. As the engine cools, the coolant is automatically drawn back into the cooling system to maintain the correct level.

9 The coolant level in the reservoir should be checked regularly. Unscrew the coolant reservoir cap and withdraw the dipstick to check the coolant level.

***Warning:** Do not remove the radiator cap to check the coolant level when the engine is warm (see illustration).*



4.9b Withdraw the dipstick from the reservoir and make sure the coolant level is between the two marks but near the upper mark with the engine warm

4.14 Flip the windscreen washer fluid cap (arrow) up to add fluid. It is on the driver's side of the engine compartment

The level in the reservoir varies with the temperature of the engine. When the engine is cold the level should be at or slightly above the lower mark on the dipstick (see illustration). Once the engine is warmed up, the level should be near or at the upper mark on the dipstick. If it isn't, unscrew the dipstick cap and add a 50/50 mixture of ethylene glycol based antifreeze and water (see **Caution** above).

10 In order to maintain the proper ratio of antifreeze and water, always top up the coolant level with the correct mixture. An empty plastic milk jug or bleach bottle makes an excellent container for mixing coolant. Do not use rust inhibitors or additives except as specified in Chapter 3 of this manual.

11 If the coolant level drops consistently, there may be a leak in the system. Inspect the radiator, hoses, filler cap, drain plugs and water pump (see Section 10). If no leaks are noted, have the radiator cap or surge tank cap pressure tested by a service station.

12 If you have to remove the radiator cap, wait until the engine has cooled completely, then wrap a thick cloth around the cap and turn it to the first stop. If coolant or steam escapes, let the engine cool down longer, then remove the cap.

13 Check the condition of the coolant as well. It should be relatively clear. If it is brown or rust colored, the system should be drained, flushed and refilled. Even if the coolant appears to be normal, the corrosion inhibitors wear out, so it must be renewed at the specified intervals.

WASHER FLUID

Refer to illustration 4.14

14 Fluid for the windscreen washer is located in a plastic reservoir on the driver's side of the engine compartment (see illustration). In milder climates, plain water can be used in the reservoir, but it should be kept no more than two-thirds full to allow for expansion if the water freezes. In colder climates, use windscreen washer system antifreeze, available at any auto parts store, to lower the freezing point of the fluid. Mix the antifreeze with water in accordance with the manufacturer's directions on the container.

***Caution:** Do not use cooling system antifreeze - it will damage the vehicle's paint.*

15 To help prevent icing in cold weather, warm the windscreen with the defroster before using the washer.

BATTERY ELECTROLYTE

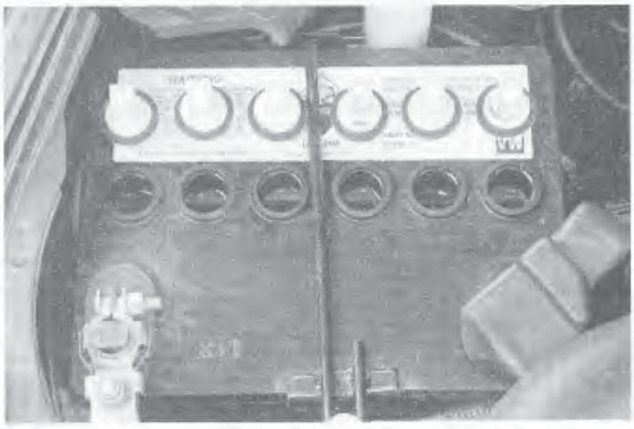
Refer to illustration 4.16

16 If a conventional-type battery has been refitted on the vehicle, remove all the cell caps on top of the battery (see illustration). If the electrolyte level is low, add distilled water until the level is above the plates. There is usually a split-ring indicator in each cell to help you judge when enough water has been added. Add water until the electrolyte level is just up to the bottom of the split ring indicator. Do not overfill the battery or it will spew out electrolyte when it is charging.

BRAKE AND CLUTCH FLUID

Refer to illustration 4.17

17 The brake master cylinder is located on the front of the power booster unit in the engine compartment (see illustration). The clutch master cylinder reservoir is mounted to the left of the brake reservoir.



4.16 Remove all six caps and check the level in each one

4.17 Make sure the brake fluid level is near the MAX mark on the reservoir - clean the area around the cap before unclipping it

18 The brake and clutch reservoirs can be checked visually. Make sure the level is above the plastic seam on the brake reservoir and at the MAX line on the clutch reservoir.

19 When adding fluid, pour it carefully into the reservoir to avoid spilling it on surrounding painted surfaces. Be sure the specified fluid is used, since mixing different types of brake fluid can cause damage to the system. See *Recommended lubricants and fluids* at the front of this Chapter or your owner's manual.

> ***Warning:*** *Brake fluid can harm your eyes and damage painted surfaces, so use extreme caution when handling or pouring it. Do not use brake fluid that has been standing open or is more than one year old. Brake fluid absorbs moisture from the air. Excess moisture can cause a dangerous loss of braking effectiveness.*

20 At this time the fluid and master cylinder can be inspected for contamination. The system should be drained and refilled if deposits, dirt particles or water droplets are seen in the fluid.

21 After filling the reservoir to the proper level, make sure the cap is on tight to prevent fluid leakage.

22 The brake fluid level in the master cylinder will drop slightly as the pads at each wheel wear down during normal operation. If the master cylinder requires repeated replenishing to keep it at the proper level, this is an indication of leakage in the brake system, which should be corrected immediately. Check all brake lines and connections, referring to Section 2 for more information.

23 If, when checking the brake master cylinder fluid level, you find one or both reservoirs to be empty or nearly empty, the brake system should be bled (see Chapter 9).

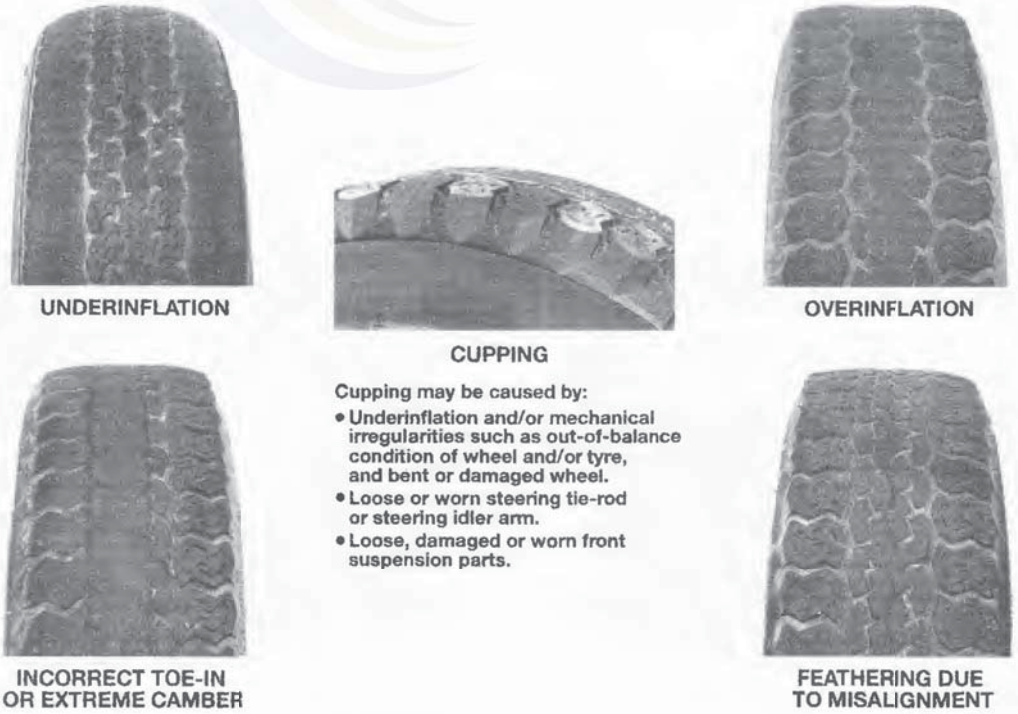
5.2 Use a tyre tread depth gauge to monitor tyre wear - they are available at auto parts stores and service stations and cost very little

5 Tyre and tyre pressure checks (every 400 kilometres or weekly)

Refer to illustrations 5.2, 5.3, 5.4a, 5.4b and 5.8

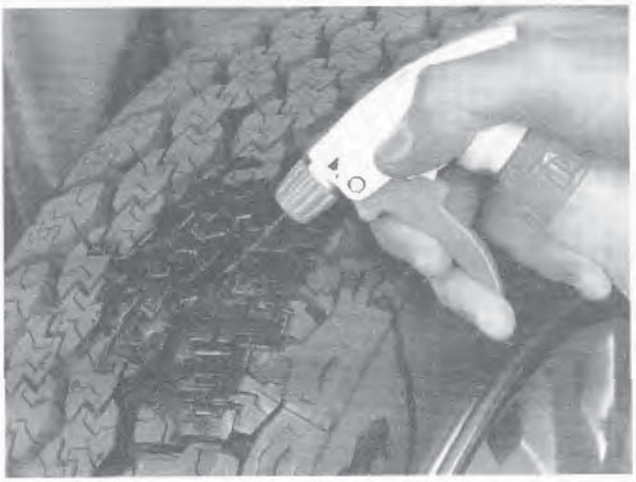
1 Periodic inspection of the tyres may spare you the inconvenience of being stranded with a flat tyre. It can also provide you with vital information regarding possible problems in the steering and suspension systems before major damage occurs.

2 Tread wear can be monitored with a simple, inexpensive device known as a tread depth indicator (see illustration).



5.3 This chart will help you determine the condition of the tyres, the probable cause(s) of abnormal wear and the corrective action necessary

5.4a If a tyre loses air on a steady basis, check the valve core first to make sure it's snug (special inexpensive tools are commonly available at auto parts stores)



5.4b If the valve core is tight, raise the corner of the vehicle with the low tyre and spray a soapy water solution onto the tread as the tyre is turned slowly - leaks will cause small bubbles to appear

3 Note any abnormal tread wear (see illustration). Tread pattern irregularities such as cupping, flat spots and more wear on one side than the other are indications of front end alignment and/or balance problems. If any of these conditions are noted, take the vehicle to a tyre shop or service station to correct the problem.

4 Look closely for cuts, punctures and embedded nails or tacks. Sometimes a tyre will hold air pressure for short time or leak down very slowly after a nail has embedded itself in the tread. If a slow leak persists, check the valve stem core to make sure it's tight (see illustration). Examine the tread for an object that may have embedded itself in the tyre or for a "plug" that may have begun to leak (radial tyre punctures are repaired with a plug that's refitted in a puncture). If a puncture is suspected, it can be easily verified by spraying a solution of soapy water onto the suspected area (see illustration). The soapy solution will bubble if there's a leak. Unless the puncture is unusually large, a tyre shop or service station can usually repair the tyre.

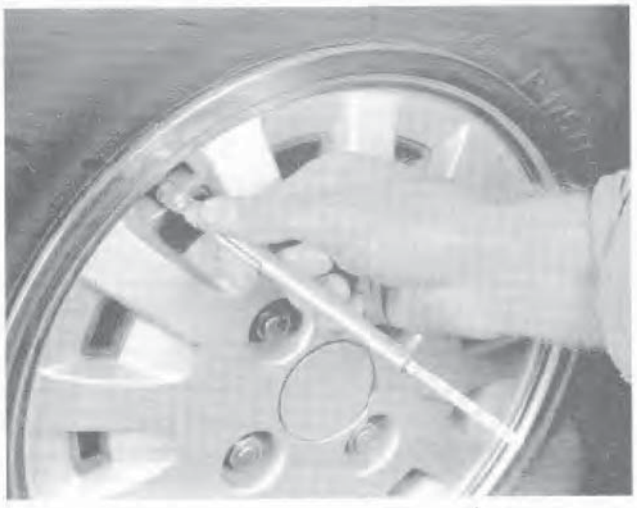
5 Carefully inspect the inner sidewall of each tyre for evidence of brake fluid. If you see any, inspect the brakes immediately.

6 Correct air pressure increases the lifespan of the tyres, improves fuel economy and enhances overall ride quality. Tyre pressure cannot be accurately estimated by looking at a tyre, especially if it's a radial. A tyre pressure gauge is essential. Keep an accurate gauge in the vehicle. The pressure gauges attached to the nozzles of air hoses at service stations are often inaccurate.

7 Always check tyre pressure when the tyres are cold. Cold, in this case, means the vehicle has not been driven over a kilometre in the three hours preceding a tyre pressure check. A pressure rise of 27 to 55 kPa is not uncommon once the tyres are warm.

8 Unscrew the valve cap protruding from the wheel or hubcap and push the gauge firmly onto the valve stem (see illustration). Note the reading on the gauge and compare the figure to the recommended tyre pressure shown on the label attached to the inside of the glove compartment door. Be sure to refit the valve cap to keep dirt and moisture out of the valve stem mechanism. Check all four tyres and, if necessary, add enough air to bring them up to the recommended pressure.

9 Don't forget to keep the spare tyre inflated to the specified pressure (refer to your owner's manual or the tyre sidewall).

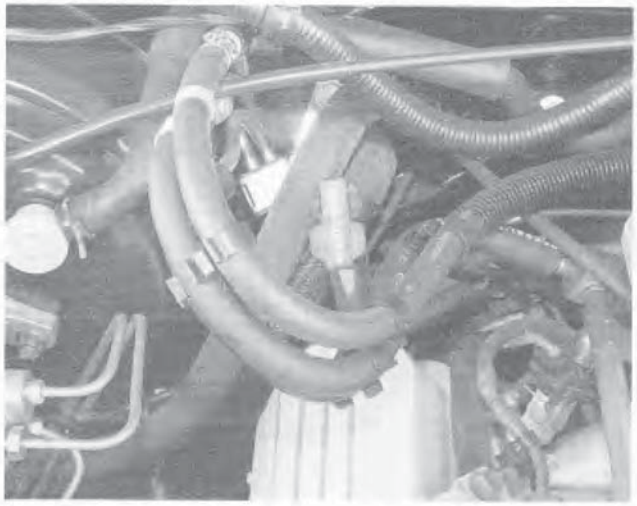


5.8 To extend the life of the tyres, check the air pressure at least once a week with an accurate gauge (don't forget the spare)

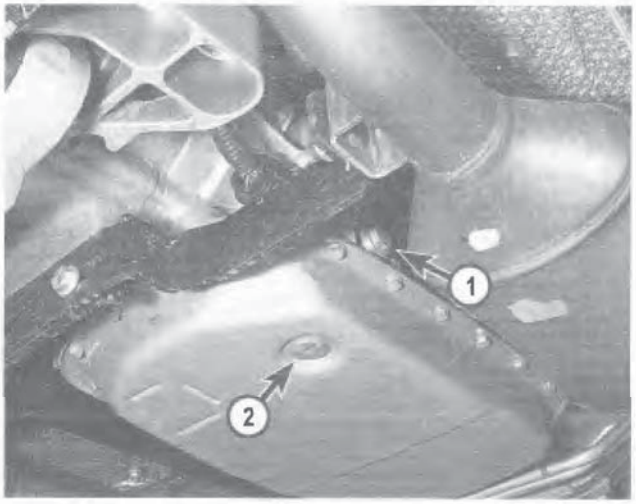
6 Automatic transmission fluid level check (every 5,000 kilometres or 3 months)

Refer to illustration 6.3a and 6.4b

1 The automatic transmission fluid level should be carefully maintained. Low fluid level can lead to slipping or loss of drive, while overfilling can cause foaming, leaking and loss of fluid.



6.3a The automatic transmission fluid dipstick is located at the rear of the engine compartment. Press the lever down to lock it in position



6.4b Five speed automatic transmission level plug (1) and drain plug (2)

Warning: *VZ V6 High output models use the 5L40-E five speed transmission. This particular transmission does not have a dipstick to check fluid level. The fluid level is checked at a filler plug on the LH side of the transmission housing, just above the rear corner of the sump. To accurately check the fluid level on this transmission, the engine must be running in Park and the vehicle has to be raised off the ground. There is a risk of personal injury from hot transmission fluid and also from the nearby exhaust system. Therefore if attempting this procedure, wear heat proof gloves and position yourself beneath the vehicle so you are not at risk of being splashed by any transmission fluid. Do not remove the filler plug unless the engine is running at idle and in Park, as the transmission fluid drains from the torque converter once the engine is switched off and flows back to the sump. If removed with the engine Off, a large amount of transmission fluid will be expelled from the filler plug hole.*

2 With the parking brake set, start the engine, then move the shift lever through all the gear ranges, ending in Park. The fluid level must be checked with the vehicle level and the engine running at idle. The automatic transmission must be at operating temperature to obtain an accurate fluid level reading.

Note: *Incorrect fluid level readings will result if the vehicle has just been driven at high speeds for an extended period, in hot weather in city traffic, or if it has been pulling a trailer. If any of these conditions apply, wait until the fluid has cooled (about 30 minutes).*

3 On models with a dipstick, check the fluid level as follows:

a) Remove the dipstick from the filler tube. The dipstick is located at the rear of the engine compartment (see illustration).
b) Carefully touch the fluid at the end of the dipstick, to determine if the fluid is cool, warm or hot. Wipe the fluid from the dipstick with a clean rag and push it back into the filler tube until the cap seats.
c) Pull the dipstick out again and note the fluid level.
d) If the fluid felt cool, the level should be within the lower marks on the dipstick. If it felt warm or hot, the level should be within the upper areas on the dipstick. If additional fluid is required, pour it directly into the tube using a funnel. It takes about half a litre to raise the level from the lower mark to the upper edge with a hot transmission, so add the fluid a little at a time and keep checking the level until it's correct.

4 On models without a dipstick, check the fluid level as follows:

a) Raise the vehicle and support it securely on jackstands.

Note: *The vehicle must be level to accurately check the automatic transmission fluid, so it will be necessary to raise both the front and rear of the vehicle.*

Warning: *Never get beneath the vehicle when it is supported only by a jack. The jack provided with your vehicle is designed solely for raising the vehicle to remove and renew the wheels. Always use jackstands to support the vehicle when it becomes necessary to place your body underneath the vehicle.*

b) Ensure the engine is idling in Park and remove the filler plug from the LH side of the transmission (see illustration).

Warning 1: *Place a drain tin beneath the filler plug to catch any fluid that may come from the filler plug.*

Warning 2: *Position your body clear of the filler plug hole as hot transmission fluid can cause burns. Also take care as the exhaust is positioned close to the filler plug.*

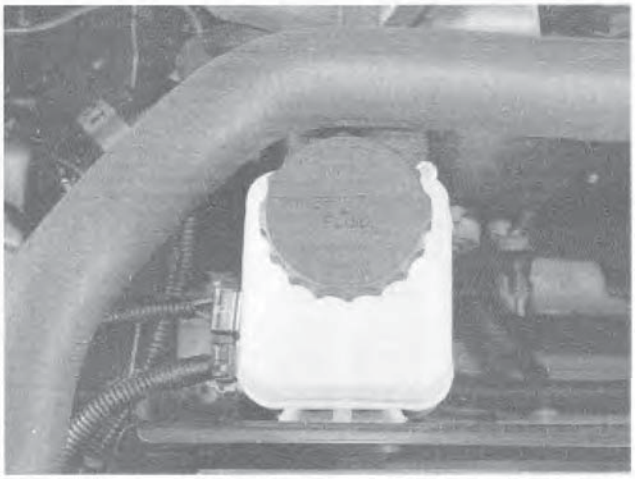
c) Use a small screwdriver as a dipstick to check the level of the fluid. The level is correct if the fluid is level with the bottom of the filler plug hole.

5 The condition of the fluid should also be checked along with the level. If the fluid at the end of the dipstick is a dark reddish-brown colour, or if the fluid has a burned smell, the fluid should be changed. If you're in doubt about the condition of the fluid, purchase some new fluid and compare the two for colour and smell.

7 Power steering fluid level check (every 5,000 kilometres or 3 months)

Refer to illustrations 7.2

1 Unlike manual steering, the power steering system relies on fluid which may, over a period of time, require replenishing.



7.2 The V6 engine power steering fluid reservoir is located near the front (drivebelt end) of the engine; turn the cap anticlockwise for removal

2 The fluid reservoir for the power steering pump is located at the front of the engine on V6 and 5.7 litre Generation III and Generation IV V8 models and can be checked visually (see illustration).

3 On 5.0 litre V8 engines the reservoir is mounted on the power steering pump and is checked with a dipstick located in the cap. For the check, the front wheels should be pointed straight ahead and the engine should be off.

4 Use a clean rag to wipe off the reservoir cap and the area around the cap. This will help prevent any foreign matter from entering the reservoir during the check.

5 Twist off the cap and check the temperature of the fluid at the end of the dipstick with your finger.

6 Wipe off the fluid with a clean rag, reinsert it, then withdraw it and read the fluid level. The level should be at the HOT mark if the fluid was hot to the touch. It should be at the COLD mark if the fluid was cool to the touch.

7 If additional fluid for either type reservoir is required, pour the specified type directly into the reservoir, using a funnel to prevent spills.

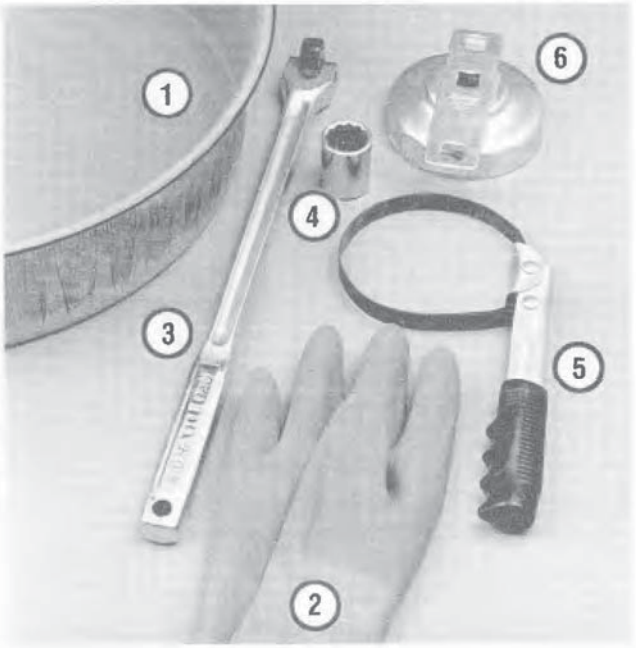
8 If the reservoir requires frequent fluid additions, all power steering hoses, hose connections, the power steering pump and the rack and pinion assembly should be carefully checked for leaks.

8 Engine oil and filter change (every 5,000 kilometres or 3 months)

Refer to illustrations 8.2, 8.7, 8.12a, 8.12c, 8.13a and 8.13b

1 Frequent oil changes are the best preventive maintenance the home mechanic can give the engine, because aging oil becomes diluted and contaminated, which leads to premature engine wear.

2 Make sure you have all the necessary tools before you begin this procedure (see illustration). You should also have plenty of rags or newspapers handy for mopping up any spills.



8.2 These tools are required when changing the engine oil and filter

1 ***Drain pan*** *- It should be fairly shallow in depth, but wide to prevent spills*

2 ***Rubber gloves*** *- When removing the drain plug and filter, you will get oil on your hands (the gloves will prevent burns)*

3 ***Breaker bar*** *- Sometimes the oil drain plug is tight, and a long breaker bar is needed to loosen it*

4 ***Socket*** *- To be used with the breaker bar or a ratchet (must be the correct size to fit the drain plug)*

5 ***Filter wrench*** *- This is a metal band-type wrench, which requires clearance around the filter to be effective*

6 ***Filter wrench*** *- This type fits on the bottom of the filter and can be turned with a ratchet or breaker bar (different-size wrenches are available for different types of filters)*

3 Access to the underside of the vehicle is greatly improved if the vehicle can be lifted on a hoist, driven onto ramps or supported by jackstands.

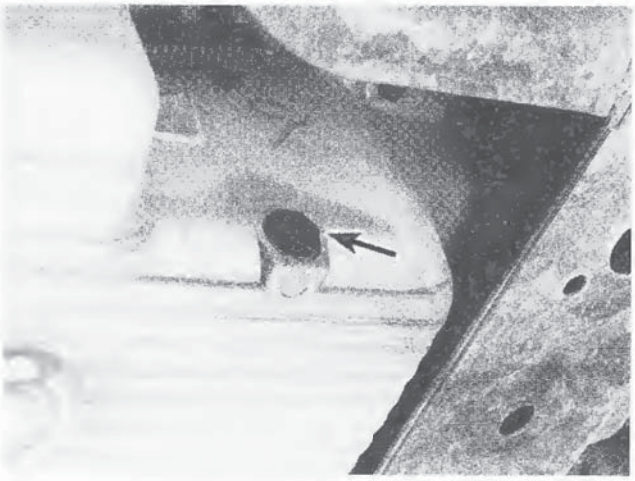
Warning: *Do not work under a vehicle which is supported only by a hydraulic or scissors-type jack.*

4 If this is your first oil change, get under the vehicle and familiarise yourself with the locations of the oil drain plug and the oil filter. The engine and exhaust components will be warm during the actual work, so try to anticipate any potential problems before the engine and accessories are hot.

5 Park the vehicle on a level spot. Start the engine and allow it to reach its normal operating temperature. Warm oil and sludge will flow out more easily. Turn off the engine when it's warmed up. Remove the filler cap from the valve cover.

6 Raise the vehicle and support it securely on jackstands.

Warning: *Never get beneath the vehicle when it is supported only by a jack. The jack provided with your vehicle is designed solely for raising the vehicle to remove and renew the wheels. Always use jackstands to support the vehicle when it becomes necessary to place your body underneath the vehicle.*



8.7 The oil drain plug (arrow) is usually very tight, so use a box-end spanner to avoid rounding off the hex

8.12a The oil filter is usually on very tight as well. It will require a special wrench for removal - DO NOT use the wrench to tighten the new filter!

7 Being careful not to touch the hot exhaust components, place the drain pan under the drain plug in the bottom of the pan and remove the plug (see illustration). You may want to wear gloves while unscrewing the plug the final few turns if the engine is hot.

8 Allow the old oil to drain into the pan. It may be necessary to move the pan farther under the engine as the oil flow slows to a trickle. Inspect the old oil for the presence of metal shavings and chips.

9 After all the oil has drained, wipe off the drain plug with a clean rag. Even minute metal particles clinging to the plug would immediately contaminate the new oil.

10 Clean the area around the drain plug opening, refit the plug and tighten it securely, but do not strip the threads. See the Specifications in this Chapter for the correct torque.

11 Move the drain pan into position under the oil filter.

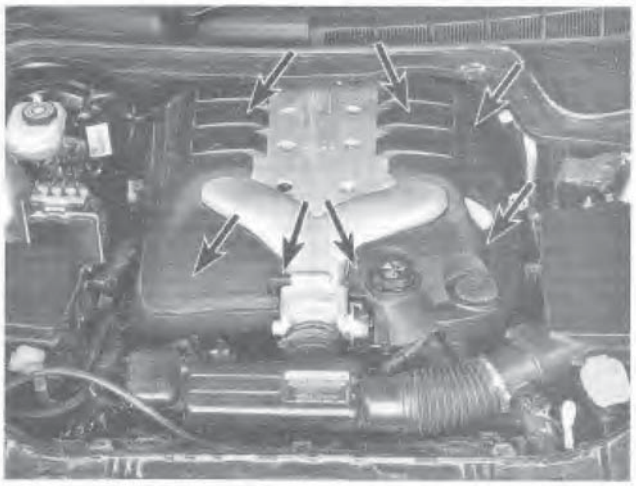
12 On all models except 3.6 litre V6 engine, change the spin-on oil filter as follows:s:

a) *Loosen the oil filter (see illustration) by turning it anticlockwise with the filter wrench. Any standard filter wrench will work. Sometimes the oil filter is screwed on so tightly that it cannot be loosened. If this situation occurs, punch a metal bar or long screwdriver directly through the side of the canister and use it as a T-bar to turn the filter. Be prepared for oil to spurt out of the canister as it is punctured. Once the filter is loose, use your hands to unscrew it from the block. Just as the filter is detached from the block, immediately tilt the open end up to prevent the oil inside the filter from spilling out.*

Warning: *The exhaust system may still be hot, so be careful.*

b) *With a clean rag, wipe off the mounting surface on the block. If a residue of old oil is allowed to remain, it will smoke when the block is heated up. Also make sure that none of the old gasket remains stuck to the mounting surface. It can be removed with a scraper if necessary.*

8.12c Lubricate the oil filter gasket with clean engine oil before refitting the filter on the engine



8.13a Release the engine cover clips to remove the LH engine cover

8.13b Removing the cap and oil filter cartridge

c) Compare the old filter with the new one to make sure they are the same type. Smear some clean engine oil on the rubber gasket of the new filter and screw it into place (see illustration). Because overtightening the filter will damage the gasket, do not use a filter wrench to tighten the filter. Tighten it by hand until the gasket contacts the seating surface. Then seat the filter by giving it an additional 3/4-turn.

13 On 3.6 litre V6 engine models, change the oil filter cartridge as follows

a) Remove the LH engine cover from the vehicle (see illustration).
b) Using a socket attached to the oil filter adapter cap, unscrew the adapter cap by rotating it anticlockwise.
c) Remove the oil filter cartridge and discard (see illustration).
d) Clean the threads of the adapter cap and the oil filter housing. Replace any O rings supplied with the new oil filter and smear clean engine oil on the threads of the adapter cap.
e) Install the adapter cap and tighten securely. See the Specifications in this Chapter for the correct torque.

14 Remove all tools, rags, etc. from under the vehicle, being careful not to spill the oil in the drain pan, then lower the vehicle.

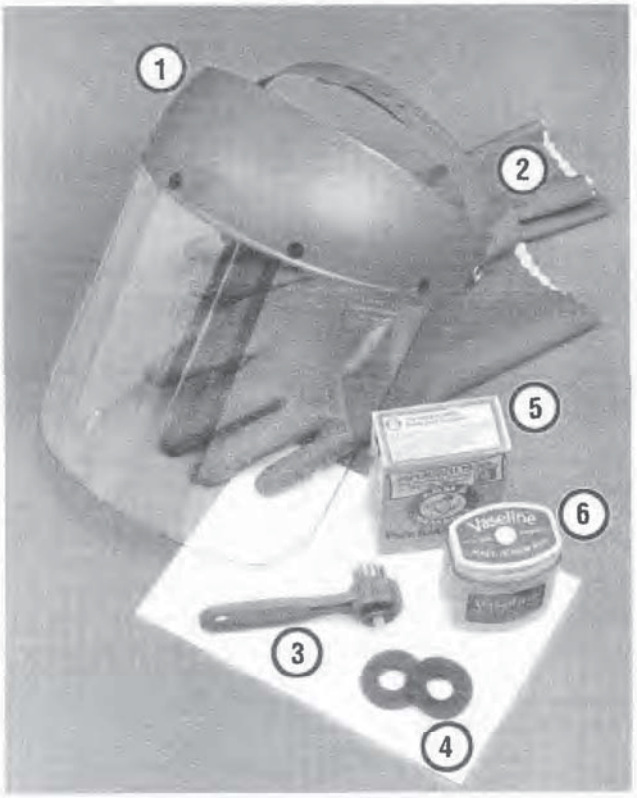
15 Add new oil to the engine through the oil filler cap in the valve cover. Use a funnel, if necessary, to prevent oil from spilling onto the top of the engine. Wait a few moments to allow the oil to drain into the pan, then check the level on the oil dipstick (see Section 4 if necessary). If the oil level is at or near the upper hole on the dipstick, refit the filler cap hand tight, start the engine and allow the new oil to circulate.

16 Allow the engine to run for about a minute. While the engine is running, look under the vehicle and check for leaks at the sump drain plug and around the oil filter. If either is leaking, stop the engine and tighten the plug or filter.

17 Wait a few minutes to allow the oil to trickle down into the sump, then recheck the level on the dipstick and, if necessary, add enough oil to bring the level to the upper hole.

18 During the first few trips after an oil change, make it a point to check frequently for leaks and proper oil level.

19 The old oil drained from the engine cannot be re-used in its present state and should be discarded. Check with your local refuse disposal company, disposal facility or environmental agency to see whether they will accept the oil for recycling. Don't pour used oil into drains or onto the ground. After the oil has cooled, it can be drained into a suitable container (capped plastic jugs, topped bottles, milk cartons, etc.) for transport to one of these disposal sites.



9.1 Tools and materials required for battery maintenance

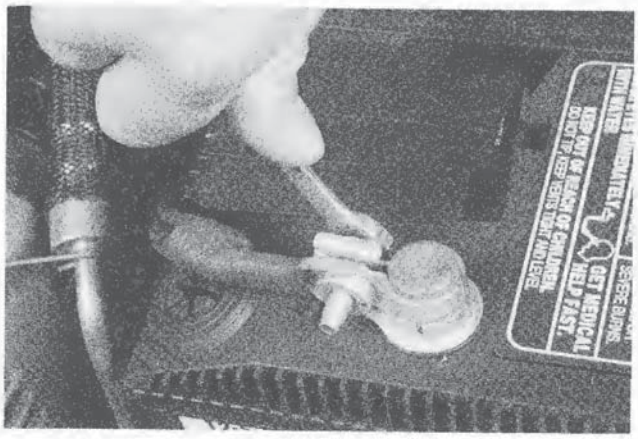
*1 **Face shield/safety goggles** - When removing corrosion with a brush, the acidic particles can easily fly up into your eyes*
*2 **Rubber gloves** - Another safety item to consider when servicing the battery - remember that's acid inside the battery!*
*3 **Battery terminal/cable cleaner** - This wire brush cleaning tool will remove all traces of corrosion from the battery and cable*
*4 **Treated felt washers** - Placing one of these on each terminal, directly under the cable end, will help prevent corrosion (be sure to get the correct type for side-terminal batteries)*
*5 **Baking soda** - A solution of baking soda and water can be used to neutralise corrosion*
*6 **Petroleum jelly** - A layer of this on the battery terminal bolts will help prevent corrosion*

9 Battery check, maintenance and charging (every 12,000 kilometres or 6 months)

Refer to illustrations 9.1, 9.4, 9.5a, 9.5b and 9.5c

***Warning:** Hydrogen gas is produced by the battery, so keep open flames and lighted tobacco away from it at all times. Always wear eye protection when working around the battery. Rinse off spilled electrolyte immediately with large amounts of water. When removing the battery cables, always detach the negative cable first and hook it up last!*

***Caution:** If the radio in your vehicle is equipped with an anti-theft system, make sure you have the correct activation code before disconnecting the battery.*



9.4 Check the tightness of the battery cable terminal bolts

1 Battery maintenance is an important procedure which will help ensure you aren't stranded because of a dead battery. Several tools are required for this procedure (see illustration).

2 A sealed battery may have been refitted in your vehicle. Although this type of battery has many advantages over the older, capped cell type, and *never* requires the addition of water, it should still be routinely maintained according to the procedures which follow.

CHECK

3 The battery is located in the front corner of the engine compartment. The exterior of the battery should be inspected periodically for damage such as a cracked case or cover.

4 Check the tightness of the battery cable terminals and connections to ensure good electrical connections and check the entire length of each cable for cracks and frayed conductors (see illustration).

5 If corrosion (visible as white, fluffy deposits) is evident, remove the cables from the terminals, clean them with a battery brush and refit the cables (see illustrations). Corrosion can be kept to a minimum by using special treated fibre washers available at auto parts stores or by applying a layer of petroleum jelly to the terminals and cables after they are assembled.

6 Make sure that the battery tray is in good condition and the hold-down clamp bolt is tight. If the battery is removed from the tray, make sure no parts remain in the bottom of the tray when the battery is refitted. When refitting the hold-down clamp bolt, do not overtighten it.

7 Information on removing and refitting the battery can be found in Chapter 5. Information on jump starting can be found at the front of this manual.

CLEANING

8 Corrosion on the hold-down components, battery case and surrounding areas can be removed with a solution of water and baking soda. Thoroughly rinse all cleaned areas with plain water.

9 Any metal parts of the vehicle damaged by corrosion should be covered with a zinc-based primer, then painted.

CHARGING

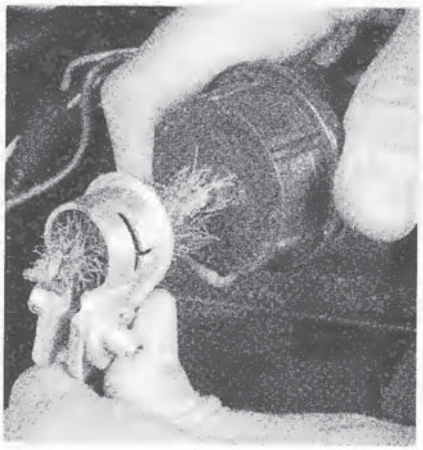
Warning: *When batteries are being charged, hydrogen gas, which is very explosive and flammable, is produced. Do not smoke or allow open flames near a charging or a recently charged battery. Wear eye protection when near the battery during charging. Also, make sure the charger is unplugged before connecting or disconnecting the battery from the charger.*

10 Slow-rate charging is the best way to restore a battery that's discharged to the point where it will not start the engine. It's also a good way to maintain the battery charge in a vehicle that's only driven a few kilometres between starts. Maintaining the battery charge is particularly important in the winter when the battery must work harder to start the engine and electrical accessories that drain the battery are in greater use.

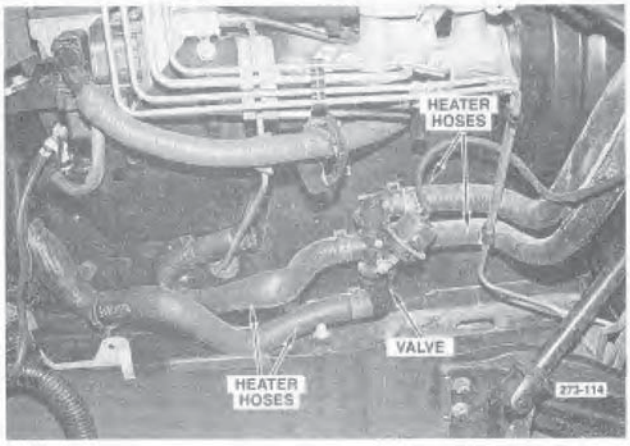
11 It's best to use a one or two-amp battery charger (sometimes called a "trickle" charger). They are the safest and put the least strain on the battery. They are also the least expensive. For a faster charge, you can use a higher amperage charger, but don't use one rated more than 1/10th the amp/hour rating of the battery. Rapid boost charges that claim to restore the power of the battery in one to two hours are hardest on the battery and can damage batteries that aren't in good condition. This type of charging should only be used in emergency situations.

9.5a These fluffy deposits must be removed before they damage the cable end

9.5b Use the brush to clean the terminal ...



9.5c ... and the cable end



10.4a Check the heater control valve for leaks

12 The average time necessary to charge a battery should be listed in the instructions that come with the charger. As a general rule, a trickle charger will charge a battery in 12 to 16 hours.

13 Remove all of the cell caps (if equipped) and cover the holes with a clean cloth to prevent spattering electrolyte. Disconnect the negative battery cable and hook the battery charger leads to the battery posts (positive to positive, negative to negative), then plug in the charger. Make sure it is set at 12-volts if it has a selector switch.

14 If you're using a charger with a rate higher than two amps, check the battery regularly during charging to make sure it doesn't overheat. If you're using a trickle charger, you can safely let the battery charge overnight after you've checked it regularly for the first couple of hours.

15 If the battery has removable cell caps, measure the specific gravity with a hydrometer every hour during the last few hours of the charging cycle. Hydrometers are available inexpensively from auto parts stores - follow the instructions that come with the hydrometer. Consider the battery charged when there's no change in the specific gravity reading for two hours and the electrolyte in the cells is gassing (bubbling) freely. The specific gravity reading from each cell should be very close to the others. If not, the battery probably has a bad cell(s).

16 Some batteries with sealed tops have built-in hydrometers on the top that indicate the state of charge of that cell by the colour displayed in the hydrometer window. Normally, a bright-colored hydrometer indicates a full charge and a dark hydrometer indicates the battery still needs charging. Check the battery manufacturer's instructions to be sure you know what the colours mean.

17 If the battery has a sealed top and no built-in hydrometer, you can hook up a digital voltmeter across the battery terminals to check the charge. A fully charged battery should read at least 12.5-volts.

10 Cooling system check (every 12,000 kilometres or 6 months)

Refer to illustrations 10.4a and 10.4b

1 Many major engine failures can be attributed to a faulty cooling system. If the vehicle is equipped with an automatic transmission, the cooling system also cools the transmission fluid and plays an important role in prolonging transmission life.

10.4b Hoses, like drivebelts, have a habit of failing at the worst possible time - to prevent the inconvenience of a blown radiator or heater hose, inspect them carefully as shown here

2 The cooling system should be checked with the engine cold. Do this before the vehicle is driven for the day or after the engine has been shut off for at least three hours.

3 Remove the radiator cap by turning it to the left until it reaches a stop. If you hear any hissing sounds (indicating there is still pressure in the system), wait until it stops. Now press down on the cap with the palm of your hand and continue turning to the left until the cap can be removed. Thoroughly clean the cap, inside and out, with clean water. Also clean the filler neck on the radiator. All traces of corrosion should be removed. The coolant inside the radiator should be relatively transparent. If it is rust colored, the system should be drained and refilled (see Section 29). If the coolant level is not up to the top, add additional antifreeze/coolant mixture (see Section 4).

4 Carefully check the large upper and lower radiator hoses along with any smaller diameter heater hoses which run from the engine to the firewall. Inspect each hose along its entire length, renewing any hose which is cracked, swollen or shows signs of deterioration. Cracks may become more apparent if the hose is squeezed (see illustrations).

5 Make sure all hose connections are tight. A leak in the cooling system will usually show up as white or rust colored deposits on the areas adjoining the leak. If wire-type clamps are used at the ends of the hoses, it may be wise to renew them with more secure screw-type clamps.

6 Use compressed air or a soft brush to remove bugs, leaves, etc. from the front of the radiator or air conditioning condenser. Be careful not to damage the delicate cooling fins or cut yourself on them.

7 Every other inspection, or at the first indication of cooling system problems, have the cap and system pressure tested. If you don't have a pressure tester, most service stations and repair shops will do this for a minimal charge.

11 Underbonnet hose check and renewal (every 12,000 kilometres or 6 months)

GENERAL

Warning: *Renewal of air conditioning hoses must be left to a dealer service department or air conditioning shop that has the equipment to depressurise the system safely. Never remove air conditioning components or hoses until the system has been depressurised.*

1 High temperatures under the bonnet can cause the deterioration of the rubber and plastic hoses used for engine, accessory and emission systems operation. Periodic inspection should be made for cracks, loose clamps, material hardening and leaks. Information specific to the cooling system hoses can be found in Section 10.

2 Some, but not all, hoses are secured to the fittings with clamps. Where clamps are used, check to be sure they haven't lost their tension, allowing the hose to leak. If clamps aren't used, make sure the hose hasn't expanded and/or hardened where it slips over the fitting, allowing it to leak.

VACUUM HOSES

3 It's quite common for vacuum hoses, especially those in the emissions system, to be colour coded or identified by colored stripes moulded into each hose. Various systems require hoses with different wall thicknesses, collapse resistance and temperature resistance. When renewing hoses, be sure the new ones are made of the same material.

4 Often the only effective way to check a hose is to remove it completely from the vehicle. If more than one hose is removed, be sure to label the hoses and fittings to ensure correct refitting.

5 When checking vacuum hoses, be sure to include any plastic T-fittings in the check. Inspect the fittings for cracks and the hose where it fits over the fitting for distortion, which could cause leakage.

6 A small piece of vacuum hose can be used as a stethoscope to detect vacuum leaks. Hold one end of the hose to your ear and probe around vacuum hoses and fittings, listening for the "hissing" sound characteristic of a vacuum leak.

Warning: *When probing with the vacuum hose stethoscope, be careful not to allow your body or the hose to come into contact with moving engine components such as the drivebelt, cooling fan, etc.*

FUEL HOSE

Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a natural gas-type appliance (such as a water heater or clothes dryer) with a pilot light is present. If you spill any fuel on your skin, rinse it off immediately with soap and water. When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand. The fuel system is under pressure, so if any lines must be disconnected, the pressure in the system must be relieved first (see Chapter 4 for more information).*

7 Check all rubber fuel lines for deterioration and chafing. Check especially for cracks in areas where the hose bends and just before fittings, such as where a hose attaches to the fuel filter and fuel injection unit.

8 High quality fuel line, usually identified by the word *Fluoroelastomer* printed on the hose, should be used for fuel line renewal. Never, under any circumstances, use unreinforced vacuum line, clear plastic tubing or water hose for fuel lines.

9 Spring-type clamps are commonly used on fuel lines. These clamps often lose their tension over a period of time, and can be "sprung" during the removal process. As a result spring-type clamps should be renewed with screw-type clamps whenever a hose is renewed.

METAL LINES

10 Sections of steel tubing often used for fuel line between the fuel pump and fuel injection unit. Check carefully for cracks, kinks and flat spots in the line.

11 If a section of metal fuel line must be renewed, only seamless steel tubing should be used, since copper and aluminium tubing do not have the strength necessary to withstand normal engine vibration.

12 Check the metal brake lines where they enter the master cylinder and brake proportioning unit (if used) for cracks in the lines and loose fittings. Any sign of brake fluid leakage calls for an immediate thorough inspection of the brake system.

12 Wiper blade inspection and renewal (every 12,000 kilometres or 6 months)

Refer to illustrations 12.5 and 12.6

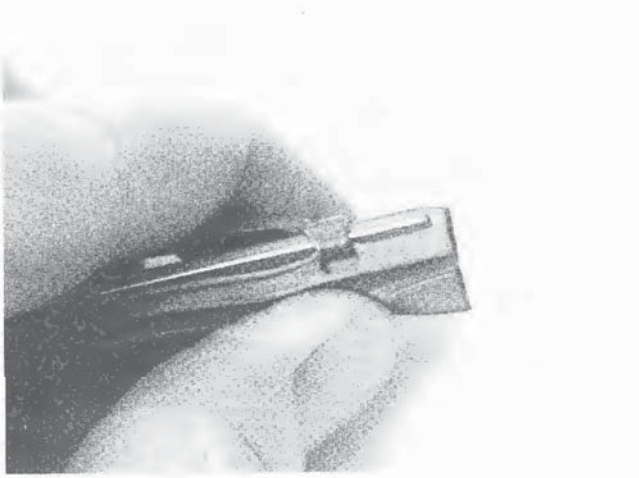
1 The windscreen and station wagon rear wiper and blade assemblies should be inspected periodically for damage, loose components and cracked or worn blade elements.

2 Road film can build up on the wiper blades and affect their efficiency, so they should be washed regularly with a mild detergent solution.

3 The action of the wiping mechanism can loosen the bolts, nuts and fasteners, so they should be checked and tightened, as necessary, at the same time the wiper blades are checked.

4 If the wiper blade elements (sometimes called inserts) are cracked, worn or warped, they should be renewed with new ones.

12.5 Depress the release lever, then slide the blade assembly out of the hook in the end of the wiper arm



12.6 Squeeze the end of the wiper element to free it from the bridge claw, then slide the element out - slide the new element in and lock it in place with the metal rods

5 Lift the arm assembly away from the glass for clearance and press on the release lever, then slide the wiper blade assembly out of the hook in the end of the arm (see illustration).

6 Use needle-nose pliers to pull out the two metal rods from the blade element, then slide the wiper blade assembly out of the frame (see illustration).

7 Compare the new element to the old one to make sure it is a direct renewal then slide it into place and insert the metal rods to secure it.

8 Refit the blade assembly on the arm, wet the windscreen and test for proper operation.

13 Suspension and steering check (every 12,000 kilometres or 6 months)

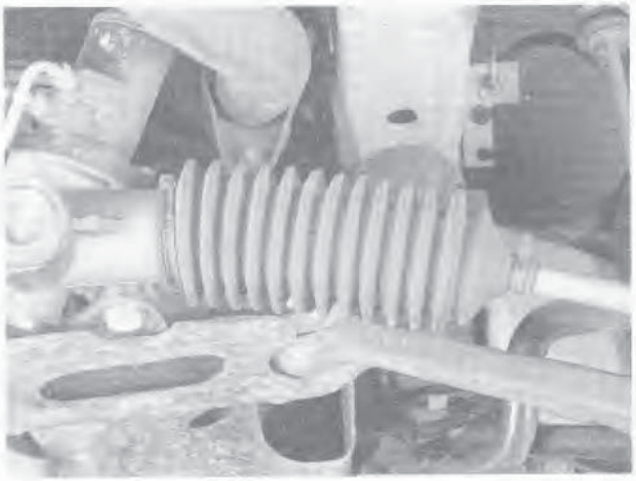
Refer to illustrations 13.4a, 13.4b, 13.5 and 13.6

1 Indications of a fault in these systems are excessive play in the steering wheel before the front wheels react, excessive sway around corners, body movement over rough roads or binding at some point as the steering wheel is turned.

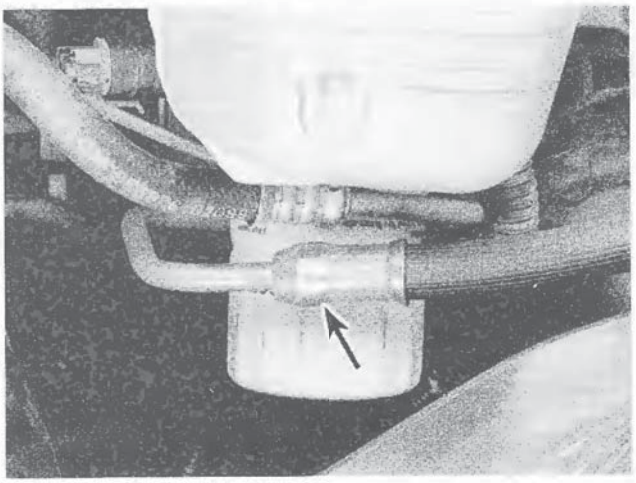
2 Raise the front of the vehicle periodically and visually check the suspension and steering components for wear. Because of the work to be done, make sure the vehicle cannot fall from the stands.

3 Check the wheel bearings. Do this by spinning the front wheels. Listen for any abnormal noises and watch to make sure the wheel spins true (doesn't wobble). Grab the top and bottom of the tyre and pull in-and-out on it. Notice any movement which would indicate a loose front wheel bearing assembly. If the bearings are suspect, renew the wheel bearing (see Chapter 10).

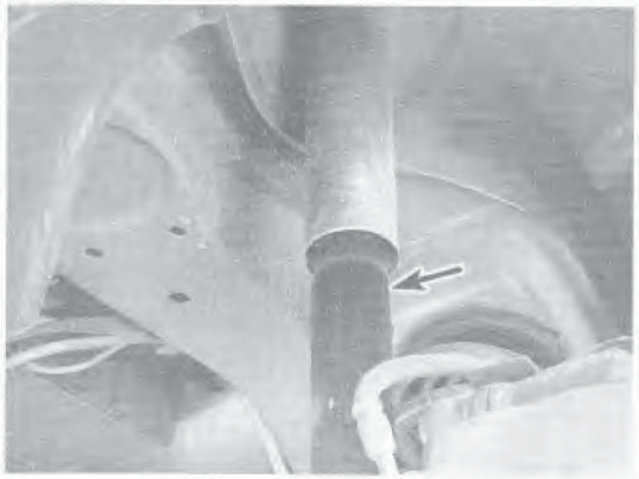
4 From under the vehicle check for loose bolts, broken or disconnected parts and deteriorated rubber bushes on all suspension and steering components. Check the steering boots for damage or leaks (see illustration). Check the power steering hoses and connections for leaks (see illustration).



13.4a Inspect the rack-and-pinion steering boots (there's one on each side) for tears or leaking grease



13.4b Make sure the power steering fluid connections (arrow) aren't leaking



13.5 Check for oil leaks in this area of the shock absorbers (arrow)

13.6 Inspect the tension rod damper (arrow) for damage and leaking fluid

5 Check the shock absorbers and/or struts for leaking fluid or damage (see illustration).

6 Inspect the front suspension tension rod damper for damage and fluid leaks (see illustration).

7 Have an assistant turn the steering wheel from side-to-side and check the steering components for free movement, chafing and binding. If the steering doesn't react with the movement of the steering wheel, try to determine where the slack is located.

14 Exhaust system check (every 12,000 kilometres or 6 months)

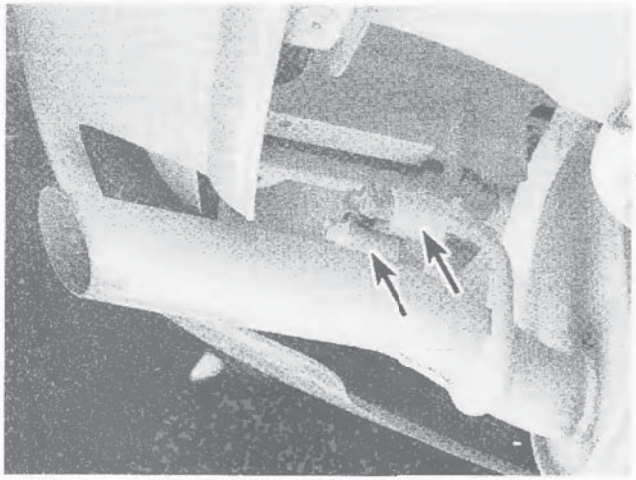
Refer to illustration 14.2a and 14.2b

1 With the engine cold (at least three hours after the vehicle has been driven), check the complete exhaust system from the engine to the end of the tailpipe. Ideally, the inspection should be done with the vehicle on a hoist to permit unrestricted access. If a hoist is not available, raise the vehicle and support it securely on jackstands.

2 Check the exhaust pipes and connections for evidence of leaks, severe corrosion and damage. Make sure that all brackets and hangers are in good condition and tight (see illustrations).

3 At the same time, inspect the underside of the body for holes, corrosion, open seams, etc. which may allow exhaust gases to enter the interior. Seal all body openings with silicone or body putty.

4 Rattles and other noises can often be traced to the exhaust system, especially the mounts and hangers. Try to move the pipes, muffler and catalytic converter. If the components can come in contact with the body or suspension parts, secure the exhaust system with new mounts.



14.2a Check the exhaust system rubber hangers (arrows) for cracks and damage

14.2b Inspect the clamps to make sure they are secure

15 Seat belt check (every 12,000 kilometres or 6 months)

1 Check the seat belts, buckles, latch plates and guide loops for obvious damage and signs of wear.
2 See if the seat belt reminder light comes on when the key is turned to the Run or Start position. A chime should also sound.
3 The seat belts are designed to lock up during a sudden stop or impact, yet allow free movement during normal driving. Make sure the retractors return the belt against your chest while driving and rewind the belt fully when the buckle is unlatched.
4 If any of the above checks reveal problems with the seat belt system, renew parts as necessary.

16 Starter safety switch check (every 12,000 kilometres or 6 months)

Warning: *During the following checks there's a chance the vehicle could lunge forward, possibly causing damage or injuries. Allow plenty of room around the vehicle, apply the parking brake and hold down the regular brake pedal during the checks.*

1 Try to start the engine in each gear. The engine should crank only in Park or Neutral.
2 Make sure the steering column lock allows the key to go into the Lock position only when the shift lever is in Park.
3 The ignition key should come out only in the Lock position.

17 Manual transmission lubricant level check (every 24,000 kilometres or 12 months)

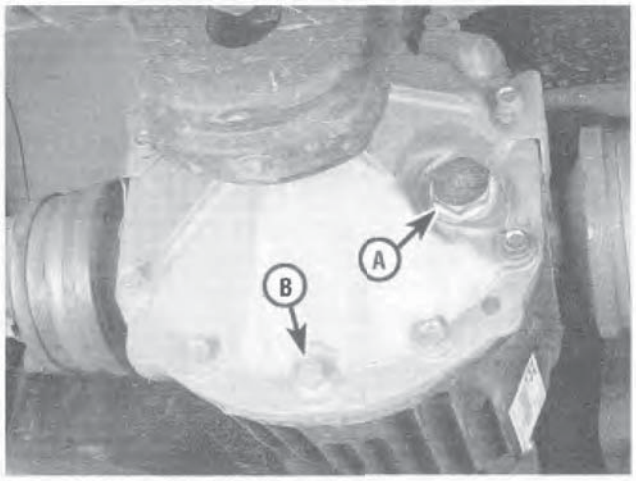
Note: *There is a drain plug as well as a fill plug on the side of the transmission. The drain plug is the lower of the two.*

1 The manual transmission has a fill plug which must be removed to check the lubricant level when the vehicle is raised to gain access to the plug, be sure to support it safely on jackstands - DO NOT crawl under a vehicle which is supported only by a jack!
2 Remove the plug from the transmission and use your little finger to reach inside the housing to feel the lubricant level. The level should be at or near the bottom of the plug hole.
3 If it isn't, add the recommended lubricant through the plug hole with a syringe or squeeze bottle.
4 Refit and tighten the plug and check for leaks after the first few kilometres of driving.

18 Differential lubricant level check (every 24,000 kilometres or 12 months)

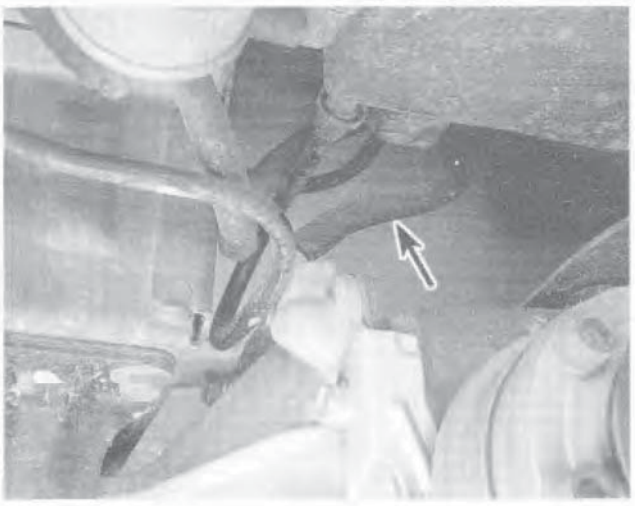
Refer to illustrations 18.2 and 18.4

1 The differential has a filler plug which must be removed to check the lubricant level. If the vehicle is raised to gain access to the plug, be sure to support it safely on jackstands - DO NOT crawl under the vehicle when it's supported only by the jack.
2 Remove the filler plug from the back of the differential (see illustration).
3 The lubricant level should be at the bottom of the plug opening. If not, use a syringe to add the recommended lubricant until it just starts to run out of the opening. A tag is located in the area of the fill tag information regarding lubricant type.
4 Inspect the differential breather hose to make sure it isn't kinked and is securely mounted (see illustration).
5 Refit the plug and tighten it securely.

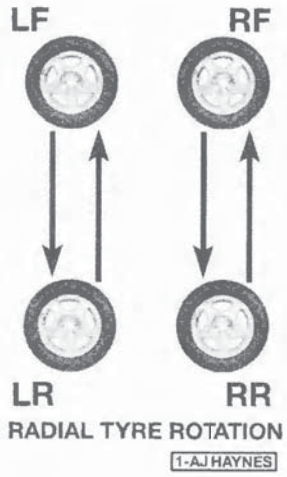


18.2 Differential plug locations

A Filler plug *B Drain plug*



18.4 Make sure the differential breather hose (arrow) is not kinked and is securely mounted at each end



19.1 Tyre rotation diagram

19 Tyre rotation (every 24,000 kilometres or 12 months)

Refer to illustration 19.1

1 The tyres should be rotated at the specified intervals and whenever uneven wear is noticed (see illustration).

2 Refer to the information in *Jacking and towing* at the front of this manual for the proper procedures to follow when raising the vehicle and changing a tyre. If the brakes are going to be checked, don't apply the parking brake as stated. Make sure the tyres are blocked to prevent the vehicle from rolling as it's raised.

3 The entire vehicle should be raised at the same time. This can be done on a hoist or by jacking up each corner and then lowering the vehicle onto jackstands placed under the frame rails. Always use four jackstands and make sure the vehicle is safely supported.

4 After rotation, check and adjust the tyre pressures as necessary and be sure to check the lug nut tightness.

20 Brake check (every 24,000 kilometres or 12 months)

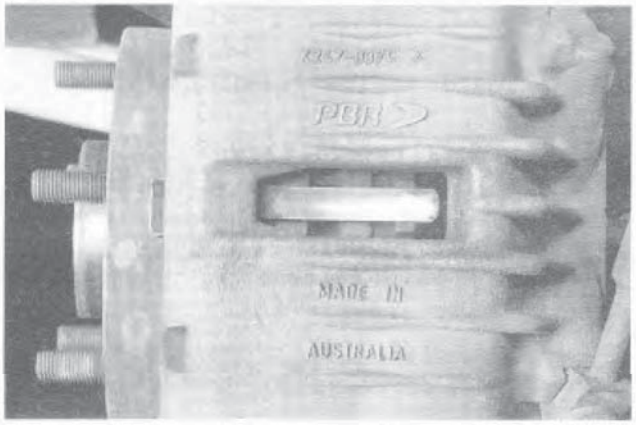
Refer to illustration 20.5

Warning: *Brake system dust may contain asbestos, which is hazardous to your health. DO NOT blow it out with compressed air or inhale it. DO NOT use petrol or solvents to remove the dust. Use brake system cleaner or denatured alcohol only.*

Note: *For detailed photographs of the brake system, refer to Chapter 9.*

1 In addition to the specified intervals, the brakes should be inspected every time the wheels are removed or whenever a defect is suspected. Raise the vehicle and place it securely on jackstands. Remove the wheels (see *Jacking and towing* at the front of this manual, if necessary).

2 Disc brakes can be checked without removing any parts except the wheels. Extensive disc damage can occur if the pads are not renewed when needed.



20.5 Look through the opening in the caliper to check the brake pads - the pad lining, which rubs against the disc, can also be inspected by looking through each end of the caliper

3 The disc brake pads have built-in wear indicators which make a high-pitched squealing sound when the pads are worn.

Caution: *Expensive damage to the disc can result if the pads are not renewed soon after the wear indicators start squealing.*

4 The disc brake calipers, which contain the pads, are visible. There is an outer pad and an inner pad in each caliper. All pads should be inspected.

5 Each caliper has a "window" to inspect the pads (see illustration). If the pad material has worn to about 3 mm thick or less, the pads should be renewed.

6 If you're unsure about the exact thickness of the remaining lining material, remove the pads for further inspection or renewal (refer to Chapter 9).

7 Before refitting the wheels, check for leakage and/or damage at the brake hoses and connections. Renew the hose or fittings as necessary, referring to Chapter 9.

8 Check the condition of the brake rotors. Look for score marks, deep scratches and overheated areas (they will appear blue or discoloured). If damage or wear is noted, the disc can be removed and resurfaced by an automotive machine shop or renewed with a new one. Refer to Chapter 9 for more detailed inspection and repair procedures.

BRAKE BOOSTER CHECK

9 Sit in the driver's seat and perform the following sequence of tests.

10 With the engine stopped, depress the brake pedal several times - the travel distance should not change.

11 With the brake fully depressed, start the engine - the pedal should move down a little when the engine starts.

12 Depress the brake, stop the engine and hold the pedal in for about 30 seconds - the pedal should neither sink nor rise.

13 Push down on the brake several times - the pedal travel should decrease with each application.

14 If your brakes do not operate as described above when the preceding tests are performed, the brake booster is either in need of repair or has failed. Refer to Chapter 9 for the removal procedure.

PARKING BRAKE

15 Slowly pull up on the parking brake and count the number of clicks you hear until the handle is up as far as it will go. The adjustment is correct if you hear the specified number of clicks. If you hear more or fewer clicks, it's time to adjust the parking brake (refer to Chapter 9).

16 An alternative method of checking the parking brake is to park the vehicle on a steep hill with the parking brake set and the transaxle in Neutral (be sure to stay in the vehicle during this check!). If the parking brake cannot prevent the vehicle from rolling, it is in need of adjustment (see Chapter 9).

21 Fuel system check (every 24,000 kilometres or 12 months)

Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a natural gas-type appliance (such as a water heater or clothes dryer) with a pilot light is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Chapter 4 for more information). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

1 The fuel system is most easily checked with the vehicle raised on a hoist so the components underneath the vehicle are readily visible and accessible.

2 If the smell of petrol is noticed while driving or after the vehicle has been in the sun, the system should be thoroughly inspected immediately.

3 Remove the fuel tank cap and check for damage, corrosion and an unbroken sealing imprint on the gasket. Renew the cap with a new one if necessary.

4 With the vehicle raised, inspect the fuel tank and filler neck for cracks and other damage. The connection between the filler neck and tank is especially critical. Sometimes a filler neck will leak due to cracks, problems a home mechanic can't repair.

Warning: *Do not, under any circumstances, try to repair a fuel tank yourself (except rubber components). A welding torch or any open flame can easily cause the fuel vapours to explode if the proper precautions are not taken.*

5 Carefully check all rubber hoses and metal lines leading away from the fuel tank. Check for loose connections, deteriorated hoses, crimped lines and other damage. Follow the lines to the front of the vehicle, carefully inspecting them all the way. Check especially the fuel filter, the external fuel pump and the fuel damper if the car is equipped with them. Repair or renew damaged sections as necessary.

6 Check the accelerator cable for freedom of movement. Lightly lubricate the cable with a couple drops of engine oil.

22 Supercharger oil level check (every 40,000 kilometres or 24 months)

1 The supercharger has a self-contained lubrication system. It does not share lubricant with the engine. The lubricant level must be checked periodically, at the specified intervals.

2 Use an Allen wrench to remove the filler plug from the nose of the supercharger (the vehicle must be parked on level ground, with the engine off and cold.

3 The lubricant level should be at the bottom of the filler plug threads. If the level is low, add the lubricant listed in the Specifications Section at the beginning of this Chapter.

Note: *Use only the specified synthetic lubricant. Use of conventional petroleum-based lubricants will damage the supercharger.*

23 Air filter renewal (every 48,000 kilometres or 24 months)

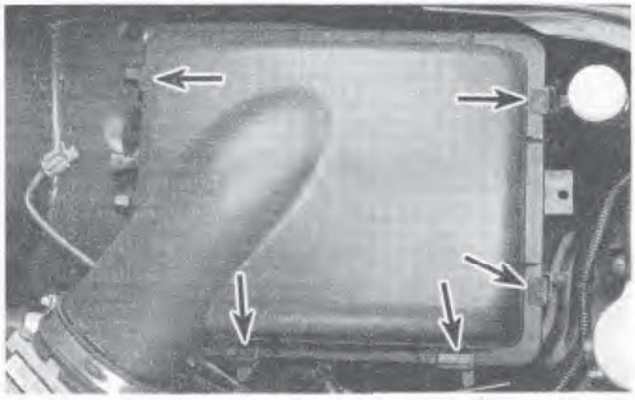
Refer to illustration 23.4a and 23.4b

1 At the specified intervals, the air filter should be renewed with a new one. The filter should be inspected between changes.

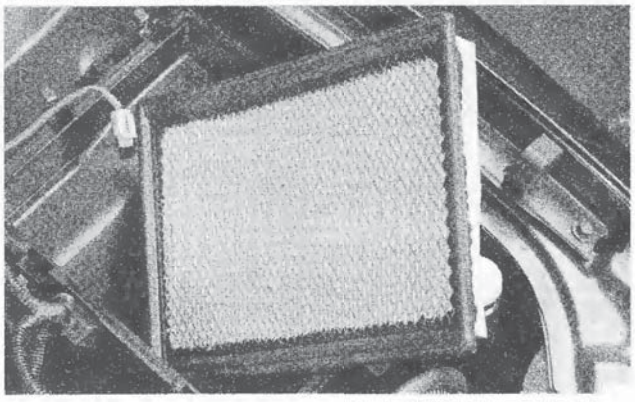
2 The air filter is located inside the air cleaner housing mounted in the left front corner of the engine compartment.

3 If necessary, loosen the clamp on the air inlet hose. Slide the hose off of the air filter housing.

4 Detach the clips, separate housing halves and lift the filter out **(see illustrations)**.



23.4a Detach the clips (arrows) and separate the air cleaner housing halves



23.4b The filter element is easily removed once the cover is off of the housing

5 While the filter housing cover is off, be careful not to drop anything down into the air cleaner assembly.
6 Wipe out the inside of the air cleaner housing with a clean rag.
7 Place the new filter in the air cleaner housing. Make sure it seats properly, seat the two halves together and secure them with the clips.
8 The remainder of refitting is the reverse of removal.

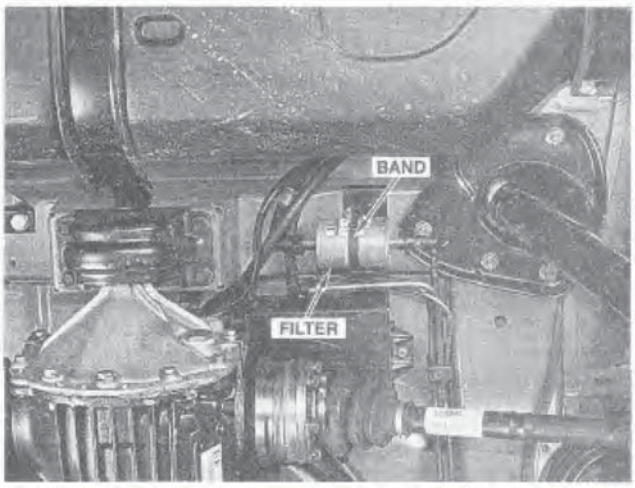
24 Fuel filter renewal (every 48,000 kilometres or 24 months)

Refer to illustration 24.4

Warning 1: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a natural gas-type appliance (such as a water heater or clothes dryer) with a pilot light is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Chapter 4 for more information). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

Warning 2: *The fuel injection system maintains considerable pressure, even with the engine off. This pressure must be relieved before working on the fuel system. Follow the fuel system pressure relief procedure in Chapter 4.*

1 Depressurise the fuel system. Refer to Chapter 4.
2 Place a container or rags under the filter. It is secured under the car near the fuel tank.
3 Carefully clamp the rubber lines using Vice-grips or small G-clamps to prevent excessive fuel from leaking out. Do not apply enough force to crush the hoses. If these tools are not available, simply work quickly.
4 Remove the hoses by squeezing the connectors and pulling straight out, then use a screwdriver to detach the retaining band (see illustration). Remove the filter.



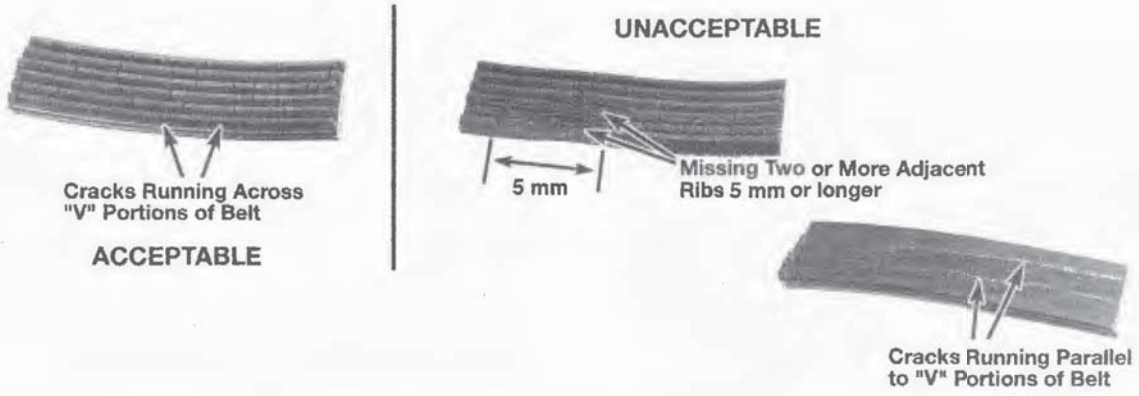
24.4 Disconnect the fuel filter lines by squeezing the connectors of the hose fittings, then use a screwdriver to detach the filter band

5 Drain the fuel from it and then test it by blowing through it from the inlet end. If it is plugged, the fuel tank may need to be cleaned also.
6 Inspect the hoses and clamps and renew them if necessary.
7 Refit the filter with the fuel direction arrow facing in the proper direction.

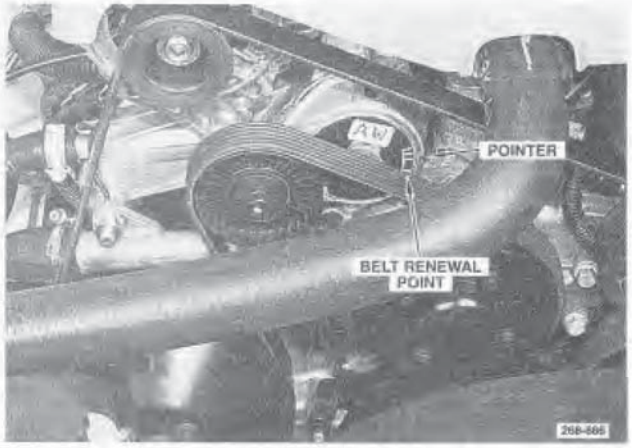
25 Drivebelt check and renewal (every 48,000 kilometres or 24 months)

Refer to illustrations 25.2, 25.4 25.5a, 25.5b, 25.12 and 25.15

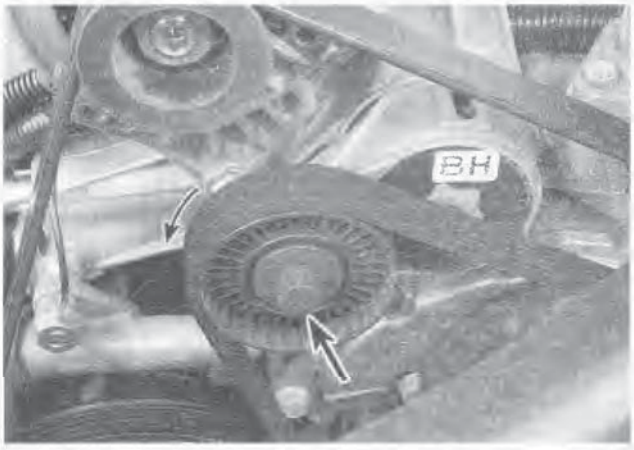
1 The drivebelts are located at the front of the engine and play an important role in the overall operation of the engine and its components. On V6 engines, a single serpentine belt drives the alternator, power steering pump, water pump and air conditioning compressor. On supercharged models, an additional separate drivebelt drives the supercharger. On V8 engines the power steering pump and air conditioner compressor are each driven by separate belts while the water pump and alternator are both driven by the same belt.



25.2 Small cracks in the underside of a V-ribbed belt are acceptable - lengthwise cracks, or missing pieces that cause the belt to make noise, are cause for renewal



25.4 Drive belt tensioner wear indicator and marks, if the indicator mark is outside the operating range, renew, the drive belt



25.5a On V6 engines, rotate the tensioner bolt (arrow) anticlockwise to remove or refit the belt

On Generation III V8 models two serpentine belts are used. Due to their function and material make up, the belts are prone to wear and should be periodically inspected.

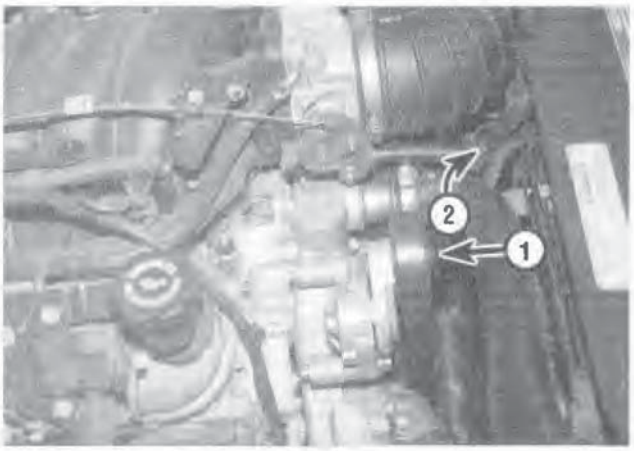
2 With the engine off, open the bonnet and use your fingers (and a flashlight, if necessary), to move along the belt checking for cracks and separation of the belt plies. Also check for fraying and glazing, which gives the belt a shiny appearance (see illustration). Both sides of each belt should be inspected, which means you have to twist the belt to check the underside.

3 Check the ribs on the underside of the belt. They should all be the same depth, with none of the surface uneven.

ALL MODELS EXCEPT 5.0 LITRE V8 MODELS

Check

4 The tension of the belt is automatically adjusted by the belt tensioner and does not require any adjustments. Drive belt wear can be checked visually by inspecting the wear indicator marks located on the front of the tensioner (see illustration) body. Locate the belt tensioner at the front of the engine on the right (drivers) side. If the indicator mark is outside the operating range, the belt should be replaced.



25.5b On Gen III V8 engines, rotate the tensioner bolt (1), clockwise (2) to remove or refit the belt

Renewal

5 To renew the belt, rotate the tensioner anti-clockwise to release belt tension (see illustration). Use a 17 mm socket with a long handle or a long ring spanner.

6 Remove the belt from the auxiliary components and slowly release the tensioner.

7 Route the new belt over the various pulleys, again rotating the tensioner to allow the belt to be refitted, then release the belt tensioner. Some models may have a decal in the engine compartment showing the proper routing of the belt.

Tensioner renewal

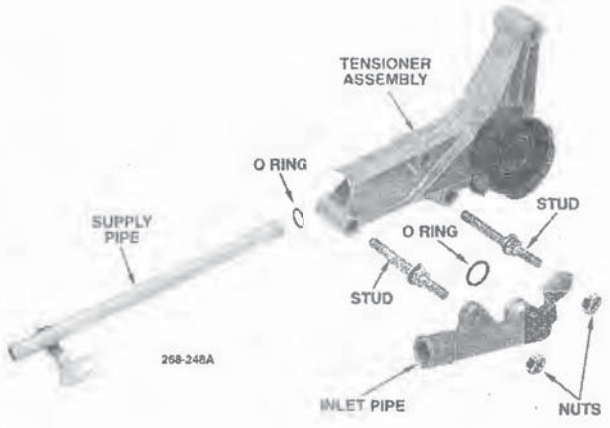
8 Remove the drivebelt as described previously.

9 Remove the alternator (see Chapter 5).

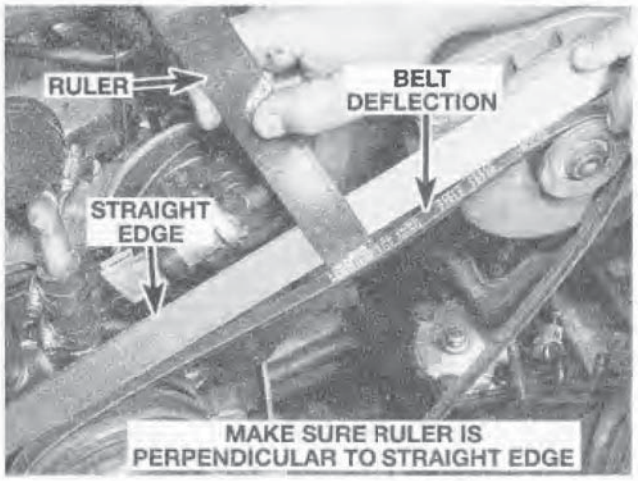
10 Drain the cooling system as described later in this Chapter and disconnect the heater hoses from the right side of the engine.

11 Remove the retaining nuts, disconnect the earth wire from the tensioner retaining stud. Remove the heater inlet pipe and discard the O-ring.

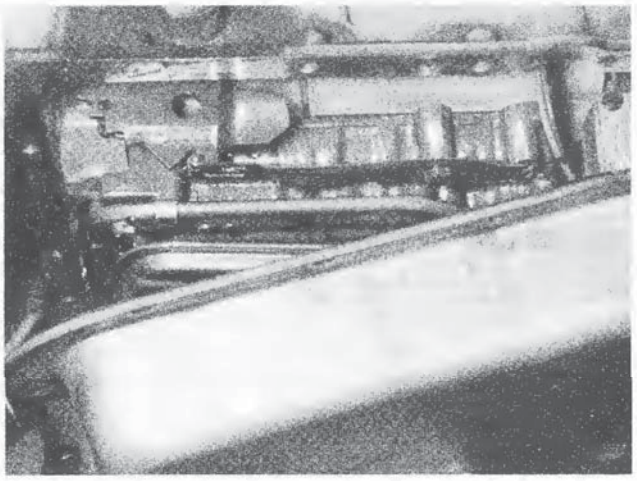
12 Remove the stud retaining the supply pipe bracket to the tensioner (see illustration) and withdraw the pipe from the tensioner assembly. Discard the O-ring.



25.12 Exploded view of the drive belt tensioner assembly



25.15 Measuring the drivebelt deflection with a straightedge and ruler



26.6 With the rear bolts in place but loose, pull the front of the pan down to drain the transmission fluid

13 Remove the studs retaining the engine drive belt tensioner assembly. Remove the tensioner assembly from the engine.

14 Refitting is the same as renewal, with the attention to the following points. Fit new O- rings and refill the cooling system.

5.0 LITRE V8 MODELS

Check

15 Check the belt tension by pushing firmly on the belt with your thumb at a distance halfway between the pulleys and note how far the belt can be pushed (deflected). Measure this deflection with a ruler (see illustration). The belt should deflect 6 mm if the distance from pulley centre to pulley centre is between 175 and 275 mm; the belt should deflect 12 mm if the distance from pulley centre to pulley centre is between 300 mm and 400 mm.

Adjustment

16 Components on this model use idler pulleys to maintain and adjust belt tension. Loosen the locknut and turn the adjusting bolt. Measure the belt tension in accordance with one of the above methods. Repeat this step until the drive-belt is adjusted.

Renewal

17 To renew a belt, follow the above procedures for drivebelt adjustment but slip the belt off the crankshaft pulley and remove it. Because the belts tend to wear out more or less together, it is a good idea to renew all belts at the same time. Mark each belt and its appropriate pulley groove so the renewal belts can be refitted in their proper positions.

18 Take the old belts to the parts store in order to make a direct comparison for length, width and design.

19 After renewing ribbed drivebelts, make sure that it fits properly in the ribbed grooves in the pulleys. It is essential that the belt be properly centred.

20 Adjust the belt(s) in accordance with the procedure outlined above.

26 Automatic transmission fluid and filter change (every 48,000 kilometres or 24 months)

Refer to illustrations 26.6, 26.9 and 26.10

1 At the specified intervals, the transmission fluid should be drained and renewed. Since the fluid will remain hot long after driving, perform this procedure only after the engine has cooled down completely.

2 Before beginning work, purchase the specified transmission fluid (see *Recommended lubricants and fluids* at the front of this Chapter) and a new filter.

3 Other tools necessary for this job include a floor jack, jack-stands to support the vehicle in a raised position, a drain pan capable of holding 5 litres, newspapers and clean rags.

4 Raise the vehicle and support it securely on jackstands.

Note: *The vehicle must be level.*

5 Place the drain pan underneath the transmission pan. Remove the front and side pan mounting bolts, but only loosen the rear pan bolts approximately four turns. On VZ 5 speed transmission, drain the fluid from the drain plug in the bottom of the pan.

6 Carefully prise the transmission pan loose with a screwdriver, allowing the fluid to drain (see illustration).

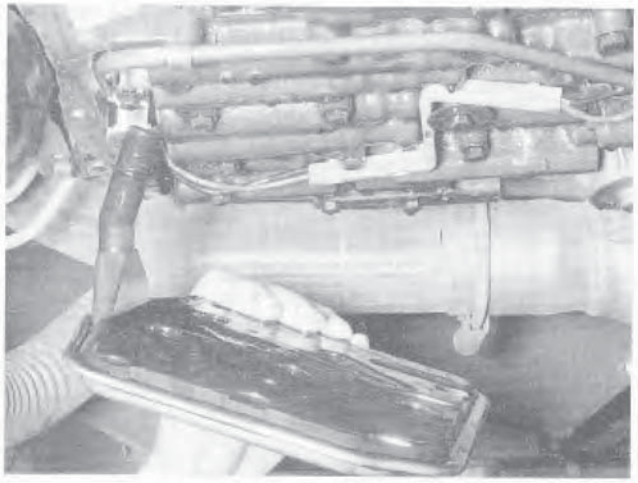
7 Remove the remaining bolts, pan and gasket. Carefully clean the gasket surface of the transmission to remove all traces of the old gasket and sealant.

8 Drain the fluid from the transmission pan, clean it with solvent and dry it with compressed air.

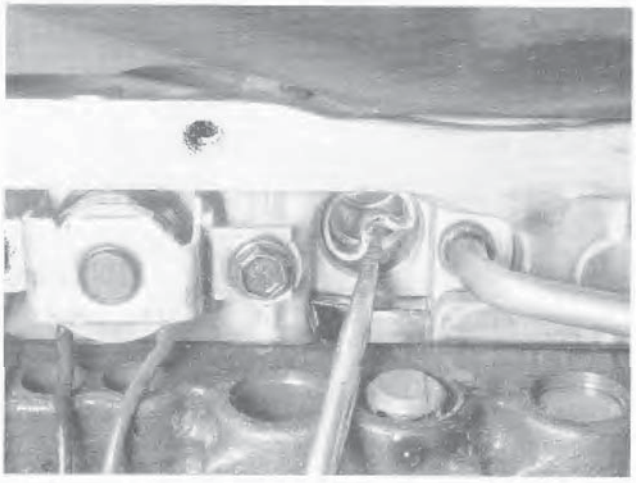
9 Remove the filter from the transmission (see illustration).

10 If the seal did not come out with the filter, remove it from the transmission (see illustration). Fit a new filter and seal.

Note: *On VZ 5 speed transmissions, there are two oil seals.*



26.9 Rotate the filter out of the retaining clip, then lower it from the transmission



26.10 If necessary, use a screwdriver to remove the seal from the transmission - be careful not to gouge the aluminium housing

11 Make sure the gasket surface on the transmission pan is clean, then fit a new gasket on the pan. Put the pan in place against the transmission and, working around the pan, tighten each bolt a little at a time until the final torque figure is reached. Keep in mind that the correct torque to avoid leaks is quite low.

12 Add new fluid to the transmission as described previously (Section 6). Check the specifications in this Chapter for the proper quantity.

> ***Note:*** *On VZ 5 speed transmissions, using a syringe or hand pump, fill the transmission until it is level with the bottom of the filler plug hole before starting the engine.*

13 With the transmission in Park and the parking brake set, run the engine at a fast idle, but don't race it.

14 Move the gear selector through each range and back to Park. Check the fluid level. It will probably be low. Add enough fluid to bring the level up to the COLD FULL range on the dipstick, or to the bottom of the filler plug hole.

15 Check under the vehicle for leaks during the first few trips.

27 Manual transmission lubricant change (every 48,000 kilometres or 24 months)

1 Raise the vehicle and support it securely on jackstands.

2 Move a drain pan, rags, newspapers and spanners under the transmission.

3 Remove the transmission drain plug at the bottom of the case and allow the lubricant to drain into the pan (see Section 17).

4 After the lubricant has drained completely, refit the plug and tighten it securely.

5 Remove the fill plug from the side of the transmission case. Using a hand pump, syringe or funnel, fill the transmission with the specified lubricant until it begins to leak out through the hole. Refit the fill plug and tighten it securely.

6 Lower the vehicle.

7 Drive the vehicle for a short distance, then check the drain and fill plugs for leakage.

28 Differential lubricant change (every 48,000 kilometres or 24 months)

1 Raise the vehicle and support it securely on jackstands.

2 Move a drain pan, rags, newspapers and spanners under the vehicle.

3 Remove the drain plug from the differential and allow the lubricant to drain into the pan (see Section 18).

4 After the lubricant has drained completely, refit the plug and tighten it securely.

5 Remove the fill plug. Using a hand pump, syringe or funnel, fill the differential with the specified lubricant until it begins to leak out through the hole. Refit the fill plug and tighten it securely.

6 Lower the vehicle.

7 Drive the vehicle for a short distance, then check the drain and fill plugs for leakage.

29 Cooling system servicing (every 48,000 kilometres or 24 months)

Refer to illustration 29.16

> ***Caution:*** *The manufacture recommends not nixing different types of antifreese or corrosion inhibitors as they may not be compatible.*

1 Periodically, the cooling system should be drained, flushed and refilled to replenish the antifreeze mixture and prevent formation of rust and corrosion, which can impair the performance of the cooling system and cause engine damage.

2 At the same time the cooling system is serviced, all hoses and the radiator cap should be inspected and renewed if defective (see Section 10).

29.16 Allow trapped air to escape by loosening this screw (arrow) - some models have more than one bleed valve

3 Since antifreeze is a corrosive and poisonous solution, be careful not to spill any of the coolant mixture on the vehicle's paint or your skin. If this happens, rinse it off immediately with plenty of clean water. Consult local authorities about the dumping of antifreeze before draining the cooling system. In many areas, reclamation centres have been set up to collect automobile oil and drained antifreeze/water mixtures, rather than allowing them to be added to the sewage system.

4 With the engine cold, remove the radiator cap. Set the heater control to the maximum setting.

5 Move a large container under the radiator to catch the coolant as it's drained.

6 Drain the radiator by opening the drain plug at the bottom. If the drain plug is corroded and can't be turned easily, or if the radiator isn't equipped with a plug, disconnect the lower radiator hose to allow the coolant to drain. Be careful not to get antifreeze on your skin or in your eyes. Loosen the V6 engine bleed screw on the water outlet two or three turns (see illustration 29.16).

7 After the coolant stops flowing out of the radiator, move the container under the engine knock sensors (V6 engines). Remove the knock sensor shields and remove the sensors (see Chapter 6) and drain the block.

8 Disconnect the hose from the coolant reservoir and remove the reservoir (see Chapter 3). Flush it out with clean water.

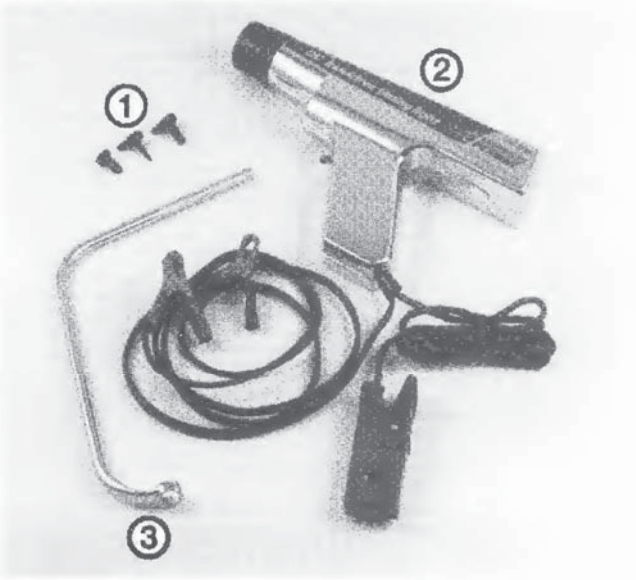
9 Place a garden hose in the radiator filler neck and flush the system until the water runs clear at all drain points.

10 In severe cases of contamination or clogging of the radiator, remove it (see Chapter 3) and reverse flush it. This involves inserting the hose in the bottom radiator outlet to allow the water to run against the normal flow, draining through the top. A radiator repair shop should be consulted if further cleaning or repair is necessary.

11 When the coolant is regularly drained and the system refilled with the correct antifreeze/water mixture, there should be no need to use chemical cleaners or descalers.

12 To refill the system, refit the knock sensor and shields, then refit the reservoir and overflow hose. Disconnect the upper radiator hose from the engine.

13 Holden recommends the addition of three special cooling system pellets whenever the system is drained. They are available at Holden dealers under part number M40124. Place them into the radiator, not into the reservoir.



30.2 Tools needed to check and adjust the ignition timing

1 ***Vacuum plugs*** *- Vacuum hoses will, in most cases, have to be disconnected and plugged. Moulded plugs in various shapes and sizes are available for this*

2 ***Inductive pick-up timing light*** *- Flashes a bright concentrated beam of light whenever the number one spark plug fires. Connect the leads according to the instructions supplied with the light*

3 ***Distributor spanner*** *- On some models, the hold-down bolt for the distributor is difficult to reach and turn with a conventional spanner or socket. A special spanner like this must be used*

14 Hold the upper radiator hose vertical and fill the system through the hose. When coolant starts to flow out of the engine, quickly attach the hose and tighten the clamp. Fill the reservoir with coolant to 25 mm above the HOT (upper) mark on the reservoir dipstick.

15 Run the engine and allow trapped air to bleed out. Add coolant as necessary. Check for leaks.

16 Loosen the V6 engine air bleed screw(s) to remove all traces of air in the system (see illustration). Add more coolant, as necessary.

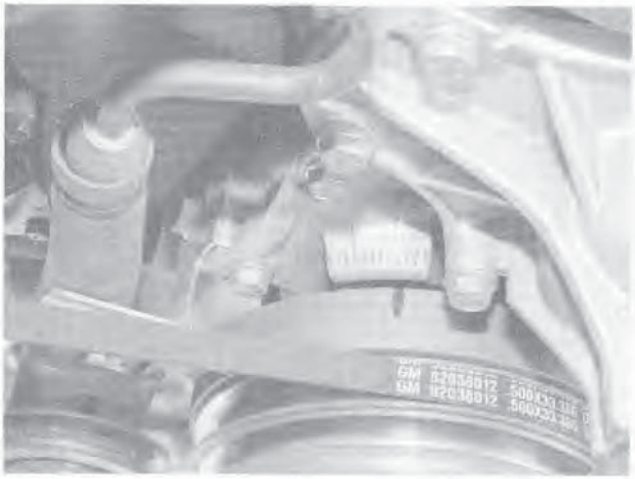
> ***Note:*** *On V6 supercharged engines there are three air bleed screws.*

17 Keep a close watch on the coolant level and the cooling system hoses during the first few kilometres of driving. Tighten the hose clamps and/or add more coolant as necessary. The coolant level should be 25 mm above the HOT (upper) mark on the reservoir dipstick with the engine at normal operating temperature.

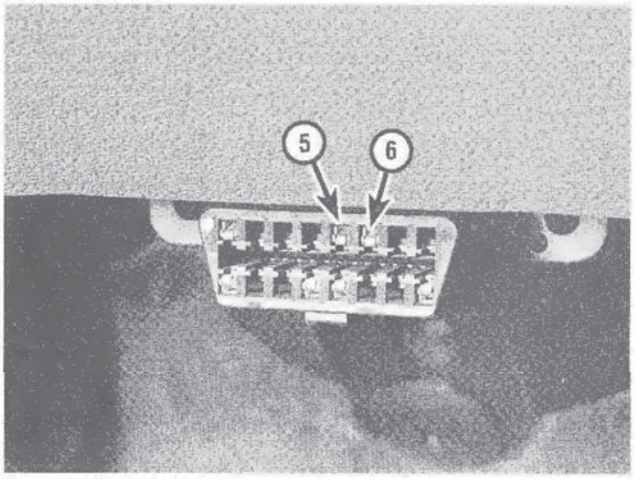
30 Ignition timing check and adjustment (V8 engines only) (every 48,000 kilometres or 24 months)

Refer to illustrations 30.2, 30.5 and 30.8

1 At the specified intervals or when the distributor has been removed, the ignition timing should be checked and adjusted.



30.5 The timing scale is attached to the front of the engine. The notch is on the crankshaft pulley.



30.8 Insert a jumper wire between terminal 5 and terminal 6

2 Obtain a timing light.

> ***Caution:*** *Make certain that the timing light is compatible with electronic ignitions. An improper timing light can damage the ignition module.*

Tools required for this procedure include an inductive pick-up timing light, a tachometer, a distributor wrench and, in some cases, a means of plugging vacuum hoses (see illustration).

3 Warm up the engine to normal operating temperature. Verify that the engine is not idling excessively high.

4 Connect the timing light in accordance with the manufacturer's instructions. Generally, it will connect to a good earth, 12 volt power and the number one spark plug wire.

> ***Note:*** *As shown in the diagram at the beginning of this Chapter, the number one spark plug is located at the front of the engine on the driver's side on 5.0L V8 engines.*

5 Locate the timing scale on the front cover of the engine adjacent to the crank-shaft pulley (see illustration). Clean it with solvent, if necessary to read the small markings.

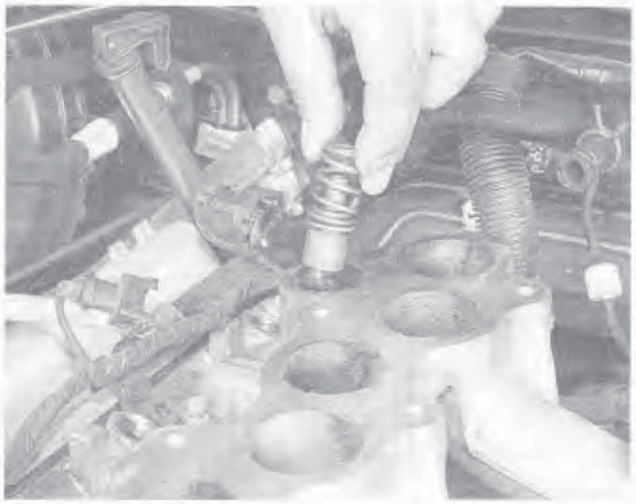
6 Use chalk or white paint to highlight the 10-degree mark on the timing scale and the groove on the crankshaft pulley.

7 Check that the wiring for the timing light is clear of all moving parts.

8 Use a paper clip or jumper wire to connect terminals 5 and 6 of the DLC (data link connector) (see illustration). Refer to Chapter 6 for its exact location.

9 Check the ignition timing with the timing light. If it requires adjustment, loosen the distributor hold-down bolt and turn the distributor until it is correct. Tighten the bolt and then re-check the timing.

10 Remove the timing light and remove the jumper wire.



31.1 The PCV valve on V6 models is in the inlet manifold concealed by a cover (components have been removed for clarity)

31 Positive Crankcase Ventilation (PCV) valve check and renewal (every 48,000 kilometres or 24 months)

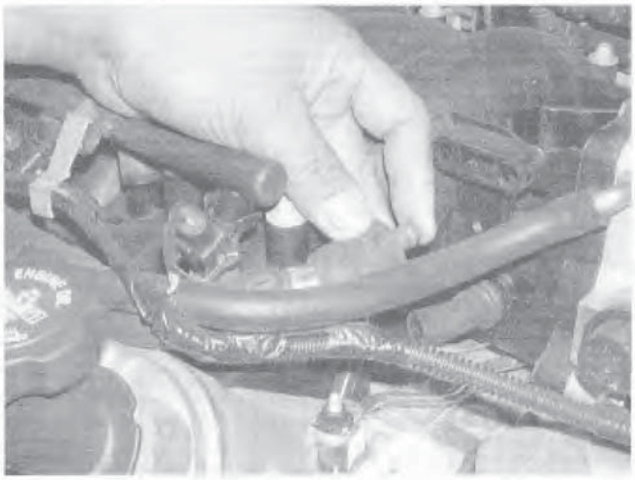
Refer to illustrations 31.1, 31.7a and 31.7b

1 On normally-aspirated models, the PCV valve is located under the rear of the inlet manifold (see illustration). On supercharged models, it is under a cover in a housing at the upper right rear of the supercharger. On V8 models, it is in the hoses between the left side valve cover and the throttle body.

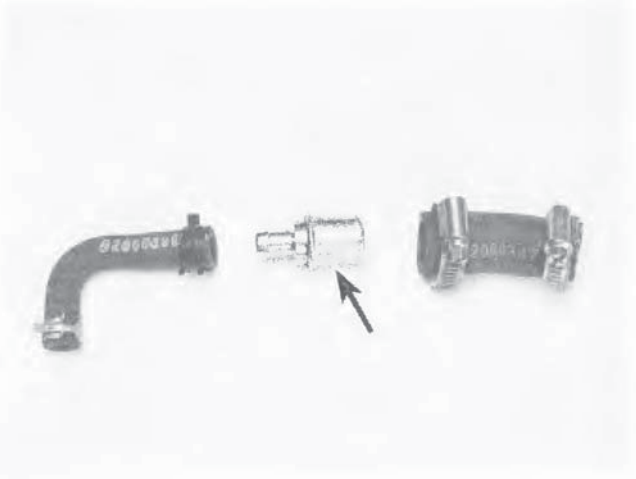
V6 MODELS

Check

2 Remove the engine oil dipstick and, with the engine running, place your finger over the dipstick tube opening. You should feel a very slight vacuum. If positive pressure or no vacuum is felt, remove the valve for further inspection. Since the vacuum is so slight, it is often helpful to lay a small piece of paper over the opening. The vacuum should hold the paper on the opening.



31.7a The PCV valve (5.7 litre Generation III V8) located at the right front valve cover - pull it out and check for vacuum with your finger



31.7b PCV valve (arrow) and hose component layout (5.0 litre V8 models)

Renewal

3 On non-supercharged models, remove the upper inlet manifold (see Chapter 2A) and lift the valve out, taking care not to lose the spring.

4 On supercharged models, unbolt and remove the spring-loaded cover at the top front of the supercharger - hold it down as you remove the screws. Remove the cover and then lay out the internal components in order as you remove them. There is a cover gasket, a spring, the PCV valve, an O-ring and a baffle beneath the cover.

5 Shake the PCV valve, listening for a rattle. If the valve doesn't rattle, renew it.

6 When purchasing a new PCV valve, make sure it's for your particular vehicle, model year and engine size. Compare the old valve with the new one to make sure they are the same.

V8 MODELS

7 With the engine idling at normal operating temperature, detach the PCV hose from the valve cover and place your finger over the end of the valve (see illustrations). If there is no vacuum at the valve, check for a plugged hose, manifold port, or the valve itself. Renew any plugged or deteriorated hoses.

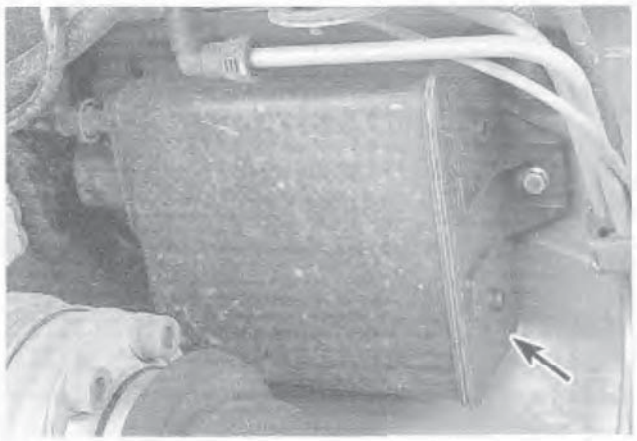
8 To renew the valve, pull it out of the end of the hose, noting its refitted position and direction.

9 When purchasing a new PCV valve, make sure it's for your particular vehicle, model year and engine size. Compare the old valve with the new one to make sure they are the same.

10 Push the valve into the end of the hose until it's seated.

11 Inspect the rubber grommet for damage and renew it with a new one if necessary.

12 Push the PCV valve and hose securely into position.



32.2 The evaporative emissions control canister(arrow) is mounted under the left side of the vehicle - check it for cracks and the hose connections for wear and damage

32 Evaporative emissions control system check (every 48,000 kilometres or 12 months)

Refer to illustration 32.2

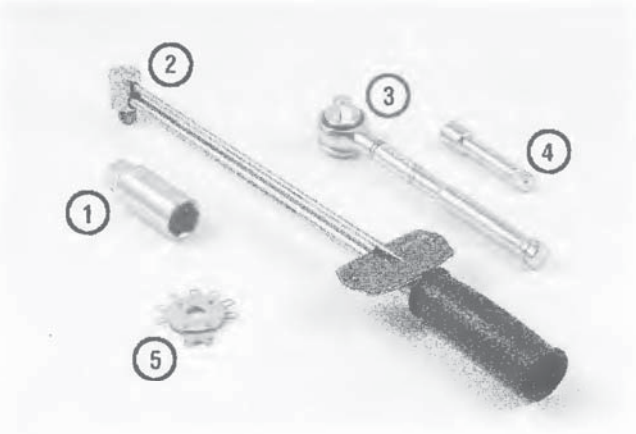
1 The function of the evaporative emissions control system is to draw fuel vapours from the fuel tank and fuel system, store them in a charcoal canister and then burn them during normal engine operation.

2 The most common symptom of a fault in the evaporative emissions system is a strong fuel odour in the engine compartment. If a fuel odour is detected, inspect the charcoal canister. Check the canister and all hoses for damage and deterioration (see illustration).

3 The evaporative emissions control system is explained in more detail in Chapter 6.

33 Spark plug renewal (every 48,000 kilometres or 24 months)

Refer to illustrations 33.2, 33.5a, 33.5b, 33.6, 33.7a, 33.7b, 33.7c, 33.9 and 33.10



33.2 Tools required for changing spark plugs

1. ***Spark plug socket*** *- This will have special padding inside to protect the spark plug's porcelain insulator*
2. ***Torque wrench*** *- Although not mandatory, using this tool is the best way to ensure the plugs are tightened properly*
3. ***Ratchet*** *- Standard hand tool to fit the spark plug socket*
4. ***Extension*** *- Depending on model and accessories, you may need special extensions and universal joints to reach one or more of the plugs*
5. ***Spark plug gap gauge*** *- This gauge for checking the gap comes in a variety of styles. Make sure the gap for your engine is included*

1 The spark plugs are located at the sides of the engine on all models except the 3.6 litre V6 engine. The 3.6 litre V6 engine has six individual ignition coils mounted to the rocker covers over each cylinder.

2 In most cases, the tools necessary for spark plug renewal include a spark plug socket which fits onto a ratchet (spark plug sockets are padded inside to prevent damage to the porcelain insulators on the new plugs), various extensions and a gap gauge to check and adjust the gaps on the new plugs (see illustration). A special plug wire removal tool is available for separating the wire boots from the spark plugs, and is a good idea on these models because the boots fit very tightly. A torque wrench should be used to tighten the new plugs. It is a good idea to allow the engine to cool before removing or refitting the spark plugs.

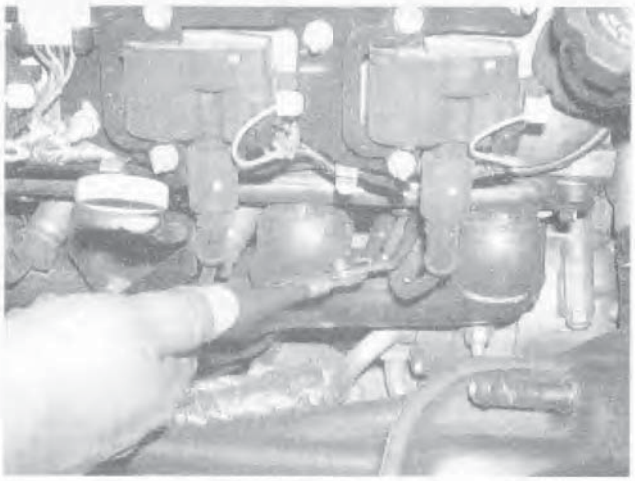
3 The best approach when renewing the spark plugs is to purchase the new ones in advance, adjust them to the proper gap and renew the plugs one at a time. When buying the new spark plugs, be sure to obtain the correct plug type for your particular engine. The plug type can be found in the Specifications at the front of this Chapter and on the Emission Control Information label located under the bonnet. If these two sources list different plug types, consider the emission control label correct.

4 Allow the engine to cool completely before attempting to remove any of the plugs. While you are waiting for the engine to cool, check the new plugs for defects and adjust the gaps.

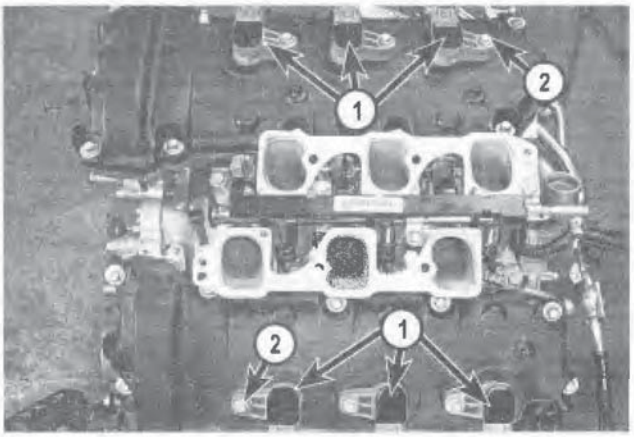
5 Check the gap by inserting the proper thickness gauge between the electrodes at the tip of the plug (see illustration). The gap between the electrodes should be the same as the one specified on the Emissions Control Information label. The wire should slide between the electrodes with a slight amount of drag. If the gap is incorrect, use the adjuster on the gauge body to bend the curved side electrode slightly until the proper gap is obtained (see illustration). If the side

33.5a Spark plug manufacturers recommend using a wire type gauge when checking the gap - if the wire does not slide between the electrodes with a slight drag, adjustment is required

33.5b To change the gap, bend the side electrode only, as indicated by the arrows, and be very careful not to crack or chip the porcelain insulator surrounding the centre electrode



33.6 When removing the spark plug wires, pull only on the boot and use a twisting, pulling motion



33.7a 3.6 litre V6 engine ignition coils (1) and two of the bolts (2)

33.7b Removing a coil from the 3.6 litre V6 engine

electrode is not exactly over the centre electrode, bend it with the adjuster until it is. Check for cracks in the porcelain insulator (if any are found, the plug should not be used). Platinum spark plugs come pre-gapped and the electrode can be easily damaged if an attempt is made to adjust them.

6 On all models except 3.6 litre V6 engine, replace the spark plugs as follows:

a) With the engine cool, remove the spark plug wire from one spark plug. Pull only on the boot at the end of the wire - do not pull on the wire. A plug wire removal tool should be used if available (see illustration).

b) If compressed air is available, use it to blow any dirt or foreign material away from the spark plug hole. A common bicycle pump will also work. The idea here is to eliminate the possibility of debris falling into the cylinder as the spark plug is removed.

7 On 3.6 litre V6 engine models, proceed as follows:

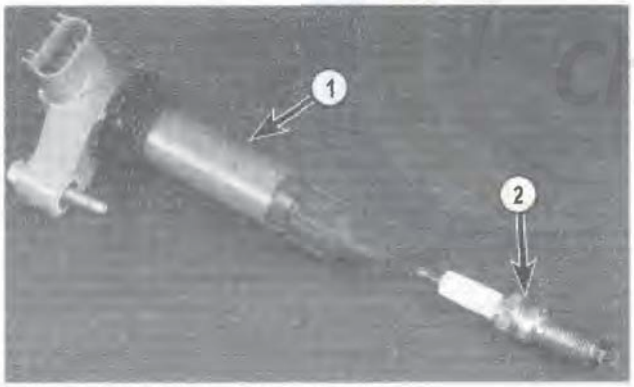
a) Remove the plenum chamber from the inlet manifold to gain access to all of the ignition coils. See Section 7 in Chapter 2B (see illustration).

b) Disconnect the wiring from each ignition coil and after loosening the retaining bolts, pull the coil from the rocker cover (see illustrations). **Note:** *The coil bolts are captive bolts. They will remain in the coil housing.*

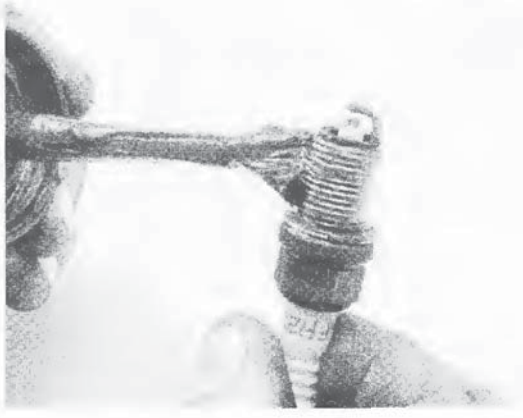
8 Place the spark plug socket over the plug and remove it from the engine by turning it in a anticlockwise direction.

9 Compare the spark plug with the chart shown on the inside back cover of this manual to get an indication of the general running condition of the engine. Before fitting the new plugs, it is a good idea to apply a thin coat of anti-seize compound to the threads (see illustration).

10 Thread one of the new plugs into the hole until you can no longer turn it with your fingers, then tighten it with a torque wrench (if available) or the ratchet. It's a good idea to slip a short length of rubber hose over the end of the plug to use as a tool to thread it into place (see illustration). The hose will grip the plug well enough to turn it, but will start to slip if the plug begins to cross-thread in the hole - this will prevent damaged threads and the accompanying repair costs.

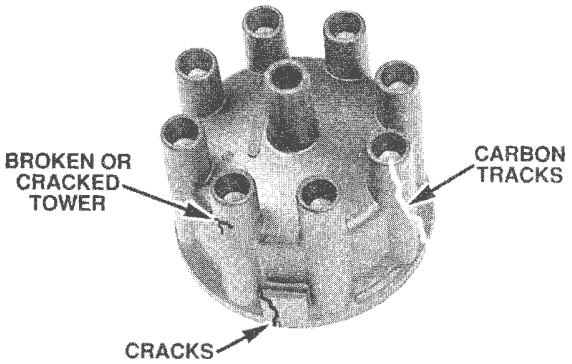


33.7c 3.6 litre V6 engine ignition coil (1) and spark plug (2)

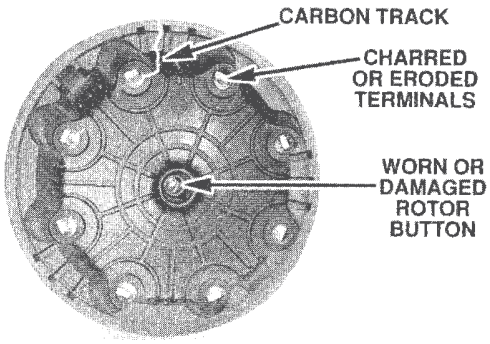


33.9 Apply a thin coat of anti-seize compound to the spark plug threads

33.10 A length of rubber hose will save time and prevent damaged threads when fitting the spark plugs



34.12a Inspect the outside of the distributor cap for damaged terminals and centre electrode and other wear and damage (if in doubt about its condition, fit a new one)



34.12b Check the inside of the distributor cap for damaged terminals well as for carbon tracks (if in doubt about its condition, fit a new one)

11 On all models except 3.6 litre V6 before pushing the spark plug wire onto the end of the plug, inspect it following the procedures outlined in Section 34. Attach the plug wire to the new spark plug, again using a twisting motion on the boot until it's seated on the spark plug.

12 On 3.6 litre V6 engine models, install the ignition coil into position, tighten the retaining bolts and connect the wiring connector.

13 Repeat the procedure for the remaining spark plugs, fitting them one at a time to prevent mixing up the spark plug wires.

14 On 3.6 litre V6 engine models, install the plenum chamber as described in Section 7 — Chapter 2B.

34 Spark plug wire, distributor cap and rotor check and renewal

Refer to illustrations 34.12a, 34.12b and 34.13

Note: V6 and 5.7 litre Generation III V8 engines are equipped with distributorless ignition systems. The spark plug wires are connected directly to the ignition coil packs. The 5.0 litre V8 engine has a conventional distributor cap and rotor.

1 The spark plug wires should be checked whenever new spark plugs are fitted.

2 Begin this procedure by making a visual check of the spark plug wires while the engine is running. In a darkened garage (make sure there is ventilation) start the engine and observe each plug wire. Be careful not to come into contact with any moving engine parts. If there is a break in the wire, you will see arcing or a small spark at the damaged area. If arcing is noticed, make a note to obtain new wires, then allow the engine to cool and check the distributor cap and rotor.

3 The spark plug wires should be inspected one at a time to prevent mixing up the order, which is essential for proper engine operation. Each original plug wire should be numbered to help identify its location. If the number is illegible, a piece of tape can be marked with the correct number and wrapped around the plug wire.

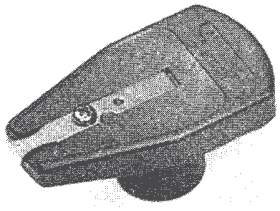
4 Disconnect the plug wire from the spark plug. A removal tool can be used for this purpose or you can grasp the rubber boot, twist the boot half a turn and pull the boot free. Do not pull on the wire itself.

5 Check inside the boot for corrosion, which will look like a white crusty powder.

6 Push the wire and boot back onto the end of the spark plug. It should fit tightly onto the end of the plug. If it doesn't, remove the wire and use pliers to carefully crimp the metal connector inside the wire boot until the fit is snug.

7 Using a clean rag, wipe the entire length of the wire to remove built-up dirt and grease. Once the wire is clean, check for burns, cracks and other damage. Do not bend the wire sharply, because the conductor might break.

8 On V6 engines, disconnect the wire from the coil pack. Again, pull only on the rubber boot.



34.13 The ignition rotor should be checked for wear and corrosion of the tip and any other cracks or damage (if in doubt about its condition, buy a new one)

5.0 LITRE V8 ENGINE DISTRIBUTOR

9 Disconnect each wire from the distributor cap. Check for corrosion and a tight fit in the same manner as the spark plug end. Renew the wires as necessary.

10 Inspect the remaining spark plug wires, making sure that each one is securely fastened at the distributor and spark plug when the check is complete.

11 If new spark plug wires are required, purchase a set for your specific engine model. Pre-cut wire sets with the boots already refitted are available. Remove and renew the wires one at a time to avoid mix-ups in the firing order.

12 Use a screwdriver to release the two clips and lift off the distributor cap. Look inside it for cracks, carbon tracks and worn, burned or loose contacts (see illustrations).

13 Remove the rotor from the distributor shaft and examine it for cracks and carbon tracks (see illustration). Renew the cap and rotor if any damage or defects are noted.

14 It is common practice to fit a new cap and rotor whenever new spark plug wires are fitted, but if you wish to continue using the old cap, check the resistance between the spark plug wires and the cap first. If the indicated resistance is more than the maximum value listed in this Chapter's Specifications, renew the cap and/or wires.

15 When fitting a new cap, remove the wires from the old cap one at a time and attach them to the new cap in the exact same location - do not simultaneously remove all the wires from the old cap or firing order mix-ups may occur.

35 Throttle body cleaning and mounting nut torque check (48,000 kilometres or 24 months)

Refer to illustration 35.4

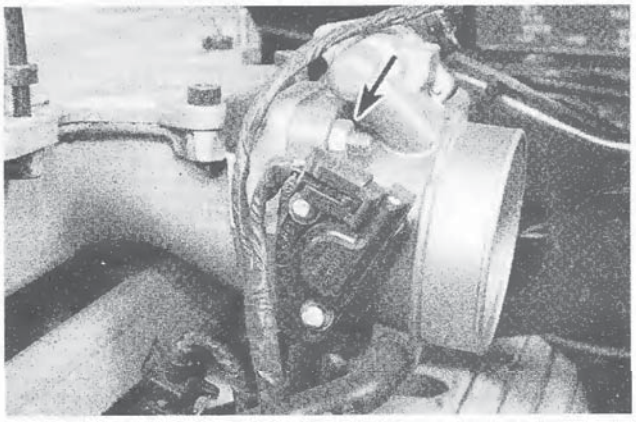
1 The throttle body fasteners can sometimes work loose from vibration and temperature changes during normal engine operation and cause a vacuum leak.

2 If you suspect that a vacuum leak exists at the throttle body, obtain a length of hose about the diameter of fuel hose. Start the engine and place one end of the hose next to your ear as you probe around the base with the other end. You should hear a hissing sound if a leak exists (be careful of hot or moving engine components).

3 Remove the entire air inlet assembly, tagging each hose to be disconnected with a piece of numbered tape to make reassembly easier.

4 Locate the mounting nuts or bolts at the throttle body (see illustration). Decide what special tools or adapters will be necessary to tighten the fasteners.

5 Tighten the nuts or bolts securely and evenly. Do not over-tighten them, as the threads could strip.



35.4 The throttle body mounting nuts (one of four shown) must be kept properly tightened to avoid vacuum leaks at the gasket

6 If, after the nuts or bolts are properly tightened, a vacuum leak still exists, the throttle body must be removed and a new gasket fitted. See Chapter 4 for more information.

7 After tightening the fasteners, refit the air cleaner and return all hoses to their original positions.

8 To service the throttle body, first loosen the clamp and remove the air inlet hose from it.

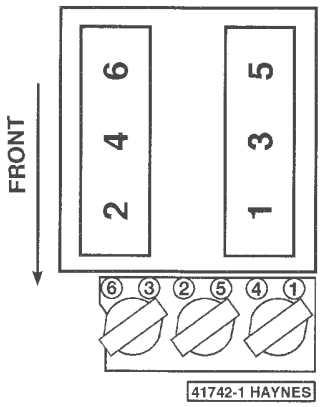
9 Spray carburettor cleaner into the throttle body and scrub off the dirt and carbon with a toothbrush or a rag. The throttle bore and the throttle blade should be cleaned of all deposits for the best possible performance.

10 Refit the air inlet hose.

Chapter 2
Engine

Part A. 3.8 litre V6 engine

Contents



Cylinder and spark plug wire terminal locations

Specifications

General

Cylinder numbers (drivebelt end-to-transmission end)	
Left bank	1-3-5
Right bank	2-4-6
Firing order	1-6-5-4-3-2
Driveplate runout maximum	0.38 mm

Camshaft

Bearing journal diameter	46.858 to 46.893 mm
Lobe lift	
Inlet	6.56 mm
Exhaust	6.48 mm
Camshaft endplay	0.04 0.26 mm

Oil pump

Outer gear-to-housing clearance	0.05 to 0.13 mm
Inner gear-to-outer gear clearance limit	0.22 mm
Gear end clearance	0.025 to 0.089 mm
Gear pocket	
Depth	9.89 to 9.92 mm
Diameter	88.70 to 88.75 mm
Pressure regulator to bore clearance	0.038 to 0.076 mm

Torque specifications

	Nm
Beaming brace to clutch housing or torque converter housing bolts	50 to 85
Beaming brace to sump bolts	20 to 35
Camshaft sprocket bolt	
Step 1	90 to 110
Step 2	Tighten an additional 90 degrees
Camshaft thrust plate screws	12 to 18
Crankshaft balancer-to-crankshaft bolt	270 to 325
Cylinder head bolts, in sequence **(see illustration 11.21)**	
Step 1	34
Step 2	Tighten an additional 90-degrees
Step 3	90
Exhaust manifold-to-cylinder head bolts/studs	40 to 60
Exhaust manifold stud nuts and bolt	20 to 27
Flywheel/driveplate-to-crankshaft bolts	
Step 1	18 to 22
Step 2	
Automatic transmission	Tighten an additional 50 degrees
Manual transmission	Tighten an additional 85 degrees
Front cover bolts	20 to 30
Inlet manifold-to-cylinder head bolts	
1997 and 1998 models	8 to 12
1999 and later models	12 to 16
Inlet manifold to plenum bolts	10 to 14

Torque specifications (continued)	Nm
Sump bolts	8 to 12
Oil filter adapter-to-timing chain cover bolts	23 to 35
Oil pump	
Cover-screws	8 to 14
Pick-up tube and screen assembly bolts	8 to 12
Rocker arm pivot bolts	
Step 1	15*
Step 2	Tighten an additional 90 degrees
Rear oil seal housing bolts	
Step 1	12 to 18*
Step 2	Tighten an additional 50 degrees
Timing chain damper retaining bolt	26
Valve cover nuts/bolts	7 to 11

** Use new bolts. Discard used bolts.*

1 General information

This Part of Chapter 2 is devoted to in-vehicle repair procedures for the 3.8 litre V6 engine.

Information concerning camshaft bearings, balance shaft and bearings, and engine removal and refitting, as well as engine block and cylinder head overhaul, is in Part E of this Chapter.

The following repair procedures are based on the assumption the engine is fitted in the vehicle. If the engine has been re-moved from the vehicle and mounted on a stand, many of the Steps included in this Part of Chapter 2 will not apply.

The Specifications included in this Part of Chapter 2 apply only to the procedures in this Part. The Specifications necessary for rebuilding the block and cylinder heads are found in Part E.

2 Repair operations possible with the engine in the vehicle

Many major repair operations can be accomplished without removing the engine from the vehicle.

Clean the engine compartment and the exterior of the engine with some type of pressure washer before any work is done. A clean engine will make the job easier and will help keep dirt out of the internal areas of the engine.

Depending on the components involved, it may be a good idea to remove the bonnet to improve access to the engine as repairs are performed (refer to Chapter 11 if necessary).

Exterior engine components such as the inlet and exhaust manifolds, the sump, the oil pump, the water pump, the starter motor, the alternator and the fuel injection system can be removed for repair with the engine in place. The timing chain and sprockets, crankshaft oil seals and cylinder head gaskets are all accessible with the engine in place.

Since the cylinder heads can be removed without pulling the engine, valve component servicing can also be accomplished with the engine in the vehicle, although it is difficult.

In extreme cases caused by a lack of necessary equipment, repair or renewal of piston rings, pistons, connecting rods and rod bearings is possible with the engine in the vehicle. However, this practice is not recommended because of the cleaning and preparation work that must be done to the components involved.

3 Top Dead Centre (TDC) for number one piston - locating

Refer to illustration 3.8

1 Top Dead Centre (TDC) is the highest point in the cylinder each piston reaches as it travels up-and-down when the crankshaft turns. Each piston reaches TDC on the compression stroke and again on the exhaust stroke, but TDC generally refers to piston position on the compression stroke.

2 Positioning the piston(s) at TDC is an essential part of certain procedures such as timing chain/sprocket removal and camshaft removal.

3 Before beginning this procedure, be sure to place the transmission in Park, apply the parking brake and block the rear wheels.

4 Remove the spark plugs (see Chapter 1).

Warning: *Make sure the ignition switch is in the Off position.*

5 When looking at the front of the engine, normal crankshaft rotation is clockwise. In order to bring any piston to TDC, the crankshaft must be turned with a socket and ratchet attached to the bolt threaded into the centre of the crankshaft balancer on the crankshaft.

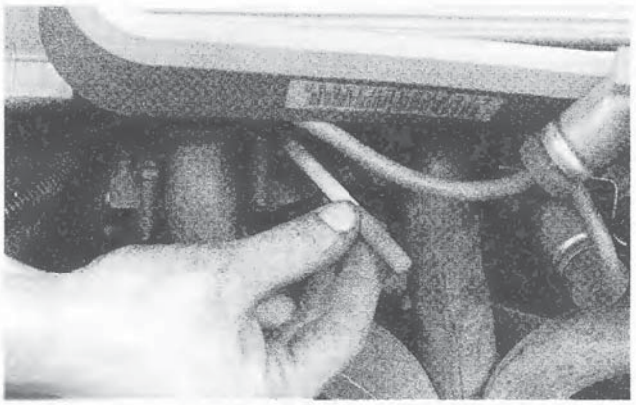
6 Have an assistant turn the crankshaft with a socket and ratchet as described above while you hold a finger over the number one spark plug hole.

Note: *See the cylinder numbering diagram in the Specifications for this Chapter.*

7 When the piston approaches TDC, air pressure will be felt at the spark plug hole. Instruct your assistant to turn the crankshaft slowly.

8 Insert a plastic pen into the spark plug hole (see illustration). As the piston rises the pen will be pushed out. Note the point where the pen stops moving out - this is TDC.

9 After the number one piston has been positioned at TDC on the compression stroke, TDC for any of the remaining pistons can be located by repeating the procedure described above and following the firing order. Divide the crankshaft pulley into three equal sections, with chalk marks at three points, indicating each 120-degrees of crankshaft rotation. The TDC position for cylinder 6, for instance, is 120-degrees after TDC for number 1.



3.8 Insert a soft plastic pen into the spark plug hole to detect piston movement. Put it in just far enough to enter the cylinder

4 Valve covers - removal and refitting

Refer to illustration 4.7

REMOVAL

1 Disconnect the negative battery cable from the battery.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

2 Remove the spark plug wires from the spark plugs and clips on the left cylinder head. For some models it will also be necessary to disconnect the cables at the coils. Number each wire before removal to ensure correct refitting.

3 Remove the dipstick tube from the stud on the exhaust manifold. Also disconnect the mass air flow sensor wiring and the air inlet tube. Move the entire tube with the mass air flow sensor out of the way.

4 Remove the valve cover mounting bolts.

5 Detach the valve cover.

> ***Note:*** *If the cover sticks to the cylinder head, use a soft-face hammer to dislodge it.*

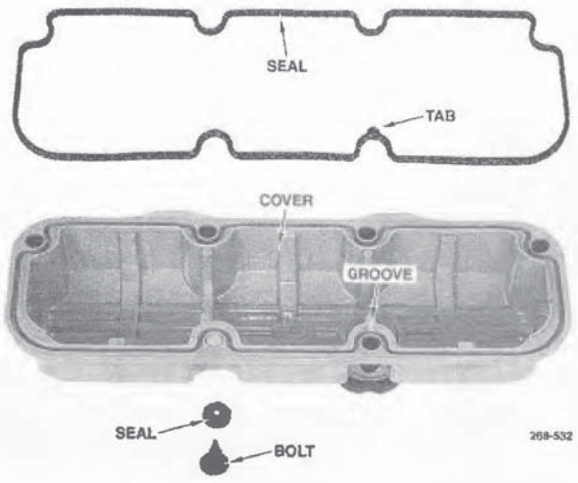
REFITTING

6 The mating surfaces of the cylinder head and valve cover must be perfectly clean when the covers are refitted. The valve covers are made of aluminium, so be extra careful not to nick or gouge the mating surfaces if you use a scraper.

7 Position a new gasket into the valve cover only if the old one is not useable. Make sure that it is refitted into the groove correctly (see illustration).

8 Place the valve cover and new gasket in position, then refit the bolts.

9 Tighten the bolts/nuts in several steps to the torque listed in this Chapter's Specifications.



4.7 Renew the valve cover gaskets only if it is necessary, align the groove with the tab on installation

10 Complete the refitting by reversing the removal procedure.

11 Start the engine and check for oil leaks at the valve cover-to-cylinder head joints.

5 Rocker arms and pushrods - removal, inspection and refitting

Refer to illustration 5.3

REMOVAL

1 Refer to Section 4 and remove the valve covers from the cylinder heads.

2 Loosen the rocker arm pivot bolts one at a time and detach the rocker arms, bolts and the retainer bar. Keep track of the rocker arm positions, since they must be returned to the same locations. Store each set of rocker arms separately in a marked plastic bag to ensure that they're refitted in their original locations. Mark each retainer bar also.

3 Remove the pushrods and store them separately to make sure they don't get mixed up during refitting (see illustration).

INSPECTION

4 Check each rocker arm for wear, cracks and other damage, especially where the pushrods and valve stems contact the rocker arm.

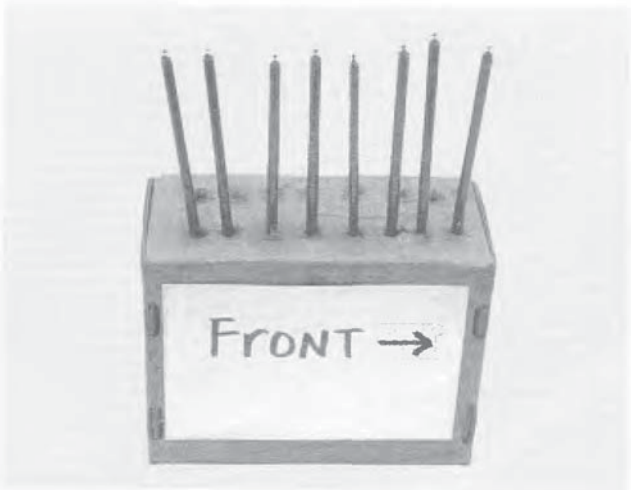
5 Check the pivot seat in each rocker arm and the pivot faces. Look for galling, stress cracks and unusual wear patterns. If the rocker arms are worn or damaged, renew them with new ones and fit new pivots or shafts as well.

6 Make sure the hole at the pushrod end of each rocker arm is open.

7 Inspect the pushrods for cracks and excessive wear at the ends. Roll each pushrod across a piece of plate glass to see if it's bent (if it wobbles, it's bent).

REFITTING

8 Lubricate the lower end of each pushrod with clean engine oil or moly-base grease and refit them in their original locations. Make sure each pushrod seats completely in the lifter socket.



5.3 Keep the pushrods organised in a specially made perforated cardboard box

9 Apply moly-base grease to the ends of the valve stems, the upper ends of the pushrods and to the pivot faces to prevent damage to the mating surfaces before engine oil pressure builds up.

10 Refit the rocker arms, pivots, retainers and bolts. Tighten the bolts to the torque listed in this Chapter's Specifications. As the bolts are tightened, make sure the pushrods seat properly in the rocker arms.

> ***Note:*** *The rocker arm bolts must be renewed with new ones whenever they are disassembled. The rocker arm bolts have a specific "stretch" when tightened. Use only factory bolts - renewal with a weaker or stronger bolt could cause valve train problems.*

11 Refit the valve covers (see Section 4).

6 Valve springs, retainers and seals - renewal

Refer to illustrations 6.4, 6.7 and 6.8

> ***Note:*** *Broken valve springs and defective valve stem seals can be renewed without removing the cylinder heads. Two special tools and a compressed air source are normally required to perform this operation, so read through this Section carefully and rent or buy the tools before beginning the job.*

1 Refer to Section 4 and remove the valve cover from the affected cylinder head. If all of the valve stem seals are being renewed, remove both valve covers.

2 Remove the spark plug from the cylinder which has the defective component. If all of the valve stem seals are being renewed, all of the spark plugs should be removed.

3 Turn the crankshaft until the piston in the affected cylinder is at Top Dead Centre on the compression stroke (refer to Section 3 for instructions). If you're replacing all of the valve stem seals, begin with cylinder number one and work on the valves for one cylinder at a time. Move from cylinder-to-cylinder following the firing order sequence (1-6-5-4-3-2).

4 Thread an adapter into the spark plug hole (see illustration) and connect an air hose from a compressed air source to it. Most auto parts stores can supply the air hose adapter.

> ***Note:*** *Many cylinder compression gauges utilize a screw-in fitting that may work with your air hose quick-disconnect fitting.*

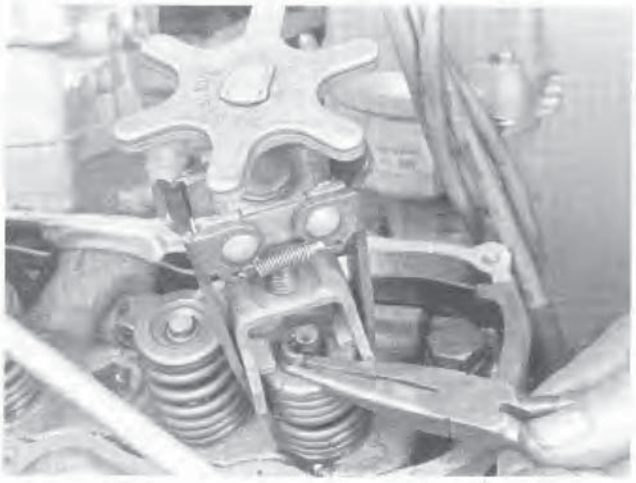
5 Remove the bolts, rocker arms and retainer for the head with the defective part and pull out the pushrod on the affected valve (see Section 5). If all of the valve stem seals are being renewed, all of the pushrods should be removed.

6 Apply compressed air to the cylinder. The valves should be held in place by the air pressure. If the valve faces or seats are in poor condition, leaks may prevent the air pressure from retaining the valves.

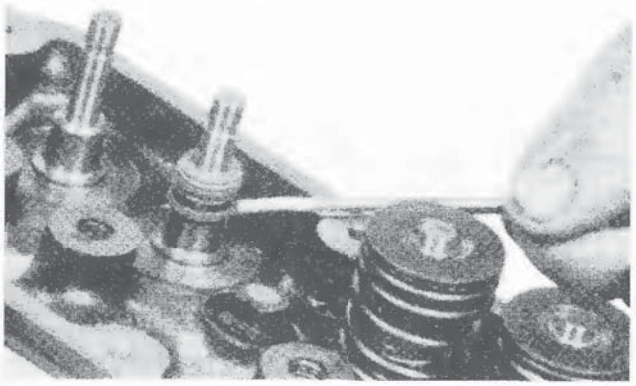
> ***Warning:*** *If the cylinder isn't exactly at TDC, air pressure may cause the engine to rotate, do not leave a socket or spanner on the balancer bolt, or you may be injured by the tool.*

7 Stuff shop rags into the cylinder head holes above and below the valves to prevent parts and tools from falling into the engine, then use a valve spring compressor to compress

6.4 This what the air hose adapter that threads into the spark plug hole looks like - they are commonly available at auto parts stores



6.7 After compressing the valve spring, remove the collets with a magnet or needle-nose pliers



6.8 A screwdriver can be used to prise off the valve seals

the spring. Remove the collets with small needle-nose pliers or a magnet (see illustration).

8 Remove the spring retainer and valve spring, then remove the guide seal (see illustration).

Note: If air pressure fails to hold the valve in the closed position during this operation, the valve face or seat is probably damaged. If so, the cylinder head will have to be removed for additional repair operations.

9 Wrap a rubber band or tape around the top of the valve stem so the valve won't fall into the combustion chamber, then release the air pressure.

10 Inspect the valve stem for damage. Rotate the valve in the guide and check the end for eccentric movement, which would indicate that the valve is bent.

11 Move the valve up-and-down in the guide and make sure it doesn't bind. If the valve stem binds, either the valve is bent or the guide is damaged. In either case, the head will have to be removed for repair.

12 Reapply air pressure to the cylinder to retain the valve in the closed position, then remove the tape or rubber band from the valve stem.

13 Lubricate the valve stem with clean engine oil and fit a new valve guide seal.

Note: Different seals are used for the inlet and exhaust valves. Some are labelled "EX" and "IN". Some are colour coded. Refer to the manufacturer's instructions.

Using a hammer and a deep socket or seal refitting tool, gently tap the seal into place until it's properly seated on the guide.

14 Refit the spring in position over the valve.

15 Refit the valve spring retainer and compress the valve spring.

16 Position the collets in the upper groove. Apply a small dab of grease to the inside of each collet to hold it in place if necessary (see illustration 12.6 in Chapter 2, Part E). Remove the pressure from the spring tool and make sure the collets are seated.

17 Disconnect the air hose and remove the adapter from the spark plug hole.

18 Refit the pushrods and rocker arms.

19 Refit the spark plug(s) and connect the wires.

20 Refer to Section 4 and refit the valve cover(s).

21 Start and run the engine, then check for oil leaks and unusual sounds coming from the valve cover area.

7 Inlet manifold- removal and refitting

Refer to illustrations 7.20 and 7.23

Note: Refer to Chapter 4 for information on the upper inlet manifold (plenum).

REMOVAL

1 Relieve the fuel system pressure (see Chapter 4).

2 Disconnect the negative battery cable from the battery.

Caution: Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.

3 Disconnect the fuel supply and return lines. Do not disconnect them at the fuel rail.

Note: Refer to Chapter 4. This procedure requires the use of a special tool to release the quick-connect fittings. These tools are available at most auto supply stores.

4 Drain the coolant from the engine (refer to Chapter 1).

5 Disconnect the air inlet duct and the mass air flow sensor and carefully set them aside (see Chapter 4). Remove the dress cover on top of the engine.

6 Disconnect the emission control lines from the throttle body.

7 Remove the right side spark plug wires from the terminals. If the wires are not already labelled, do so now. Disconnect them from the retainer and pull the wire tube away from the manifold.

8 Label and then disconnect all the vacuum hoses at the inlet manifold.

9 Remove the alternator assembly (see Chapter 5).

10 Disconnect the upper radiator hose from the engine.

11 Remove the coolant supply tube from the belt tensioner unit.

12 Loosen the heater outlet tube from the belt tensioner and remove it.

13 Remove the thermostat housing and the thermostat (refer to Chapter 3).

14 Disconnect the throttle and cruise control cables.

15 Label and then disconnect all wiring harnesses and connectors. The main harness must be pulled loose from the mounts on the inlet manifold.

16 Disconnect any heater hoses or pipes which interfere.

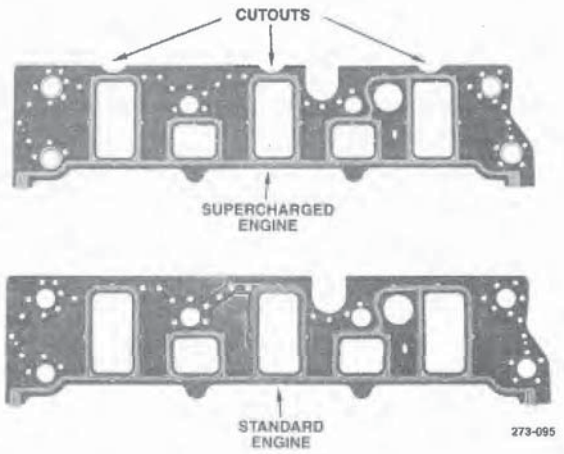
17 Remove the manifold mounting bolts, and separate the manifold from the engine. Do not prise between the manifold and heads, as damage to the gasket sealing surfaces may result. If you're fitting a new manifold, transfer all fittings and sensors to the new manifold.

REFITTING

Note: The mating surfaces of the cylinder heads, block and manifold must be perfectly clean when the manifold is refitted. Gasket removal solvents are available at most auto parts stores and may be helpful when removing old gasket material that's stuck to the heads and manifold (since the manifold is made of aluminium, aggressive scraping can cause damage). Be sure to follow the directions printed on the container.

18 Use a gasket scraper to remove all traces of sealant and old gasket material, then clean the mating surfaces with lacquer thinner or acetone. If there's old sealant or oil on the mating surfaces when the manifold is refitted, oil or vacuum leaks may develop. Use a vacuum cleaner to remove any gasket material that falls into the inlet ports or the lifter valley.

19 Use a tap of the correct size to chase the threads in the bolt



7.20 Inlet manifold gasket identification

holes, then use compressed air (if available) to remove the debris from the holes.

Warning: *Wear safety glasses or a face shield to protect your eyes when using compressed air.*

20 Apply a dab of RTV sealant to joints where the heads meet the block (four places). Refit the end seals. Make sure the pointed end of each seal fits snugly against both the head and block. The cutout parts of the seals face towards the outside of the engine (see illustration).

21 Fit the gaskets, pushing them down into the beads of sealant. Apply an additional small dab of RTV sealant to the tops of the seal ends where they meet the gaskets. Make sure that the gaskets fit correctly over the dowels.

22 Carefully lower the manifold into place. Refit the bolts finger tight, then torque them in the proper sequence.

23 Tighten the mounting bolts following the recommended sequence (see illustration) to the torque listed in this Chapter's Specifications.

24 Refit the remaining components in the reverse order of removal. Inspect and renew water sealing O-rings. Apply petroleum jelly to all O-rings before refitting them.

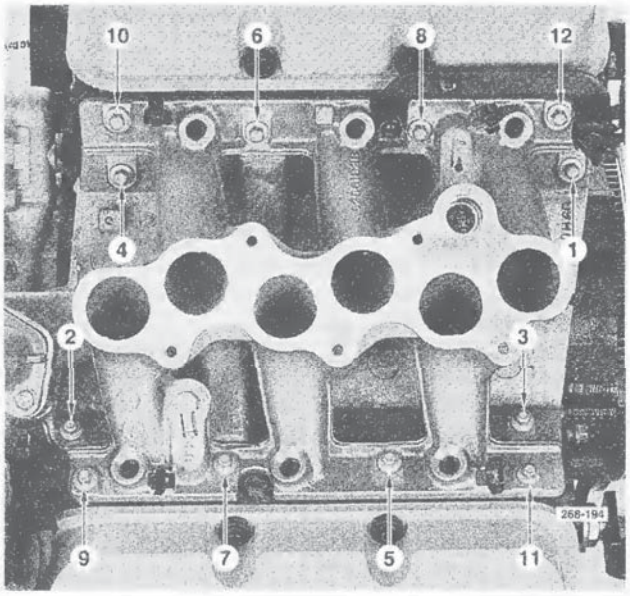
25 Change the oil and filter and fill the cooling system (see Chapter 1). Start the engine and check for oil and vacuum leaks.

8 Exhaust manifolds - removal and refitting

Warning: *Allow the engine to cool completely before beginning this procedure.*

Note: *Exhaust system fasteners are frequently difficult to remove - they get "seized" in place because of the heating/cooling cycle to which they're constantly exposed. To ease removal, apply penetrating oil to the threads of all exhaust manifold and exhaust pipe fasteners and allow it to soak in.*

1 Disconnect the negative battery cable.



7.23 Inlet manifold bolt tightening sequence

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

2 Label and then disconnect the wires from the spark plugs. Unclip the retainers and lay the wires out of the way.

3 Disconnect the wiring to the oxygen sensor if it interferes.

4 For the left manifold, disconnect the wiring to the mass air flow sensor and loosen the clamps at each end of the air inlet duct. Remove the duct and place it out of the way.

5 Remove the dipstick assembly.

6 Disconnect the EGR outlet tube from the left exhaust manifold.

7 Raise the car and support it securely on jackstands.

8 Remove the two nuts on each pipe that secure the exhaust pipe to the exhaust manifold.

9 Remove the lock nuts and the lock plates, then remove the exhaust manifold fasteners and remove the manifold.

10 Clean the mating surfaces of the manifold and cylinder head to remove all traces of old gasket material, then check the manifold for warpage and cracks. Use a precision machinist's straightedge to inspect the surface. If the manifold requires it, take it to an automotive machine shop for resurfacing.

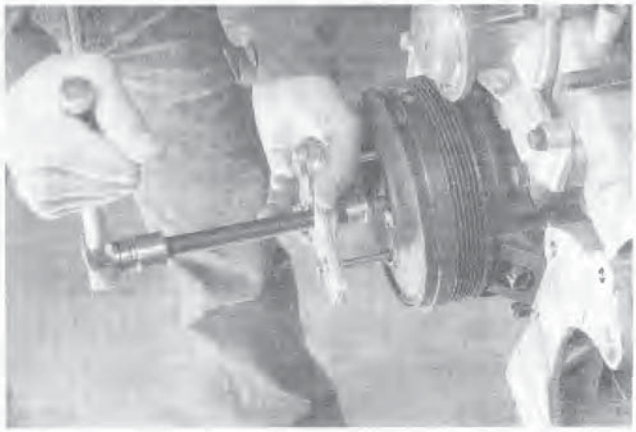
11 Place the manifold in position and fit the bolts/studs finger tight.

12 Starting in the middle and working out toward the ends, tighten the mounting bolts/studs a little at a time until all are at the torque listed in this Chapter's Specifications. Apply anti-seize to the threads of the oxygen sensor if it was removed.

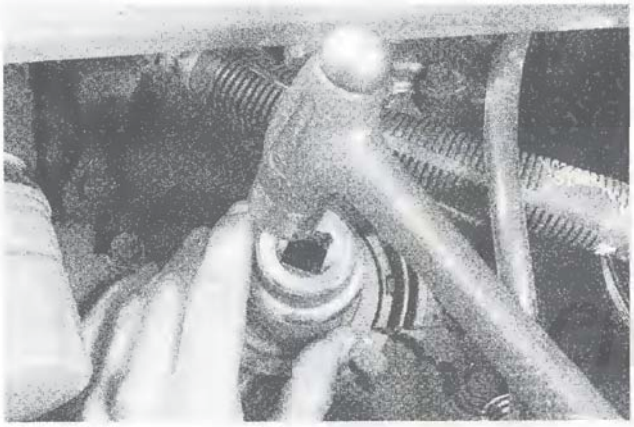
13 Refit the remaining components in the reverse order of removal.

14 Refer to Chapter 1 and refill the cooling system.

15 Start the engine and check for exhaust leaks between the manifold and cylinder head and between the manifold and exhaust pipe.



9.8 Three 6mm, fine-thread bolts will be needed to adapt your puller to the balancer - use a long Allen bolt in the crank snout for the tool's point to fit into



9.13 Gently drive the new seal into place with a hammer and a large socket

9 Crankshaft balancer and front oil seal - renewal

Refer to illustrations 9.8, 9.10 and 9.13

> ***Note:*** *The crankshaft balancer is serviced as an assembly. Do not attempt to separate the pulley from the balancer hub.*

BALANCER REMOVAL

1 Disconnect the negative cable from the battery.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

2 Remove the serpentine drivebelt (see Chapter 1).

3 Raise the vehicle and support it securely on jackstands.

4 Disconnect the wiring from the oil pressure switch.

5 Remove the balancer bolt. The crankshaft must be held from turning while loosening. If the car is not equipped with a beaming brace between the engine and transmission, it is not difficult to lock the flywheel with a large screwdriver if the starter is first removed. See Section 15 for the removal procedure for the beaming brace. It is usually easier to follow one of the following methods for locking the engine.

6 If the vehicle has a manual transmission, block the rear wheels, apply the parking brake and put it in high gear.

7 On automatic transmission equipped vehicles, screw two high strength (grade 8) bolts by hand into the recessed holes in the balancer. Don't screw them in far enough to damage the sensor behind it. Insert a long flat steel bar between the bolts and support the end of it with the frame rail. The bolt is normally very tight, so use a long breaker bar and a six-point socket.

8 A balancer puller must be used to remove the crankshaft balancer (see illustration). Leave the Woodruff key in place in the end of the crankshaft.

> ***Note:*** *The pulley and balancer are a single assembly - do not attempt to separate them.*

9 If there's a groove worn into the seal contact surface on the crankshaft balancer, sleeves are available that fit over the groove, restoring the contact surface to like-new condition. These sleeves are sometimes included with the seal kit. Check with your parts supplier for details.

> ***Note:*** *Inspect the interrupters on the back of the balancer. If they are damaged, renew the entire unit.*

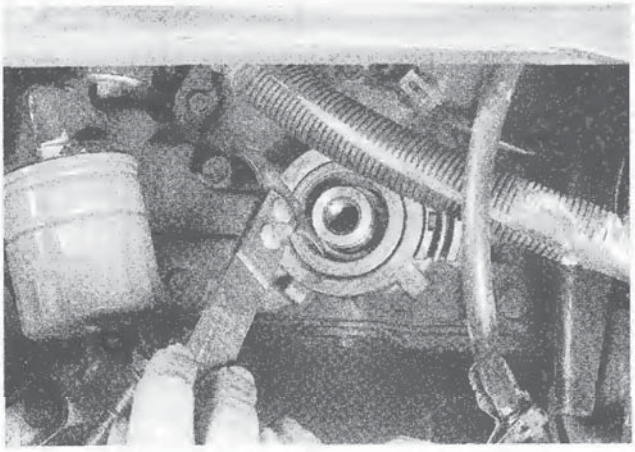
SEAL RENEWAL

10 Prise the old oil seal out with a seal removal tool or a screwdriver (see illustration). Be very careful not to nick or otherwise damage the crankshaft in the process.

11 Apply a thin coat of RTV sealant to the outer edge of the new seal. Lubricate the seal lip with moly-base grease or clean engine oil.

12 Place the seal squarely in position in the bore and press it into place with a seal driver. Make sure the seal enters the bore squarely and seats completely.

13 If a seal driver is unavailable, carefully guide the seal into place with a large socket or piece of pipe and a hammer (see illustration). The outer diameter of the socket or pipe should be the same size as the seal outer diameter.



9.10 Prise out the old seal with a seal removal tool (shown) or a screwdriver, but be careful to avoid nicking the crankshaft

14 Refitting is the reverse of removal. Align the keyway with the key and avoid bending the metal tabs. Be sure to apply moly-base grease to the seal contact surface on the back side of the balancer (if it isn't lubricated, the seal lip could be damaged and oil leakage would result).

BALANCER REFITTING

15 Apply a very small amount of RTV sealant to the crankshaft snout and to the key. Refit the crankshaft balancer. Tighten the crankshaft balancer bolt to the torque listed in this Chapter's Specifications. It will be necessary to hold the crankshaft from turning using one of the previously mentioned methods.

16 Refit the remaining parts in the reverse order of removal. Before refitting the drivebelt, rotate the crankshaft through several revolutions and make sure the interuptor rings on the backside of the balancer do not contact the crankshaft sensor.

17 Start the engine and check for oil leaks at the seal.

10 Front cover, timing chain and sprockets - removal and refitting

FRONT COVER REMOVAL

1 Disconnect the negative battery cable from the battery.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

2 Remove the crankshaft balancer (see Section 9).

3 Fully remove the water pump pulley.

4 Drain the coolant. Refer to Chapter 1.

5 Remove the lower radiator hose.

6 Remove the fan and shroud if they interfere with front cover removal.

7 Disconnect and label all interfering wiring harnesses, including those to the sensors and the spark plug wires.

8 Remove the water inlet tube from the front cover.

9 Remove the power steering pump pulley.

10 Label and disconnect the spark plug wires from the coil pack. Disconnect the wiring harness from the coil pack.

11 Remove the idler/coil pack bolts.

12 Disconnect the transmission cooler lines and the battery wiring. Move these assemblies out of the way.

13 Prise the shield from the crankshaft position sensor.

14 Set the parking brake and put the transmission in Park. Raise the front of the vehicle and support it securely on jackstands.

15 Remove the beaming brace on later models.

16 Remove the sump-to-front cover bolts and loosen the bolts that secure the sump to the block. Lower the vehicle.

17 Remove the crankshaft position sensor.

18 Remove the front cover-to-engine block bolts and studs. Remove the front cover.

CHAIN AND SPROCKET REMOVAL

Refer to illustrations 10.21, 10.22 and 10.26

19 The timing chain should be renewed with a new one if the total freeplay midway between the sprockets exceeds 25 mm (with the tensioner in position). Failure to renew the timing chain may result in erratic engine performance, loss of power and lowered fuel efficiency.

> ***Note:*** *Renewal timing chains are sold as a set, with the new chain and new camshaft and crankshaft gears; do not attempt to renew parts individually.*

20 The upper sprocket is retained by a single bolt. Loosen but do not remove the camshaft sprocket bolt.

> ***Warning:*** *The bolt is very tight. Have your socket and breaker bar securely on the bolt head at all times to avoid injury. You may have to grind the end of your socket perfectly flat in order to get it to seat solidly enough on the camshaft bolt.*

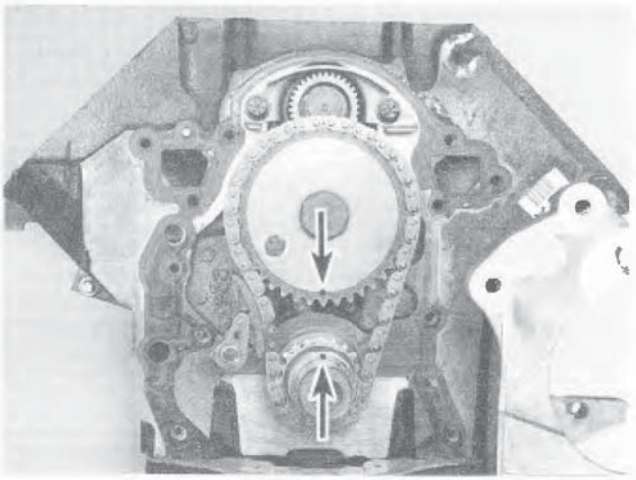
> ***Note:*** *For manual transmission vehicles, the engine can be held from turning by having an assistant apply the brakes firmly with the transmission in high gear. For automatic transmission cars, you will have to refit the balancer and use two bolts inserted into it and a long bar to lock the engine.*

21 Rotate the engine so that the timing sprocket marks align (see illustration) and then remove the bolt completely. Remove the balancer from the crankshaft.

22 Remove the camshaft sprocket while levering back the damper.

> ***Note:*** *All models use a camshaft position sensor magnet which is a loose fit in the camshaft sprocket. Do not lose it as you remove the sprocket. The damper (chain tensioner) may now be removed if necessary* (see illustration).

23 Use a gasket scraper to remove all traces of old gasket material and sealant from the cover and engine block. The cover is made of aluminium, so be careful not to nick or gouge it. Clean the gasket sealing surfaces with lacquer thinner or acetone.



10.21 Turn the crankshaft until the timing marks (arrows) align

24 The oil pump cover must be removed and the cavity packed with petroleum jelly as described in Section 14 before the cover is refitted.

25 Clean the timing chain components with solvent and dry them with compressed air (if available).

Warning: *Wear eye protection.*

26 Inspect the components for wear and damage. Look for teeth that are deformed, chipped, pitted, polished or discolored. Behind the camshaft sprocket is the gear that drives the smaller balance shaft gear, inspect the two balance shaft gears, and renew them as a set if wear is indicated.

Note 1: *Balance shaft removal, inspection and renewal is covered in Chapter 2E under camshaft and balance shaft refitting.*

Note 2: *The balance shaft drive gears must be refitted so that their marks are aligned* (see illustration).

REFITTING

Note: *If the crankshaft has been disturbed, fit the new sprocket temporarily and turn the crankshaft until the mark on the crankshaft sprocket is exactly at the top. If the camshaft was disturbed, fit the new sprocket temporarily and turn the camshaft until the timing mark is at the bottom, opposite the mark on the crankshaft sprocket.*

27 Refit the crankshaft sprocket. Assemble the timing chain to the camshaft sprocket, then slip the sprocket and chain assembly onto the crankshaft sprocket with the timing marks aligned. The chain tensioner will have to be pried out of the way if it was left in place.

28 Apply Loctite 242 to the threads and refit the camshaft sprocket bolt. Tighten it to the torque listed in this Chapter's Specifications.

29 If it was removed, attach the timing chain tensioner assembly to the block and refit the spring. The end of the spring must fit into the hole.

30 Rotate the engine through two complete revolutions and check that the timing marks still align.

31 Apply a thin layer of RTV sealant to both sides of the new front cover gasket, then position the gasket on the engine block (the dowel pins should keep it in place). Attach the cover to the engine, making sure the oil pump drive engages with the flats on the crankshaft.

32 Apply Loctite 242 to the bolt threads, then refit them finger tight. Refit the crank-shaft sensor.

33 Follow a crisscross pattern when tightening the other bolts and work up to the torque listed in this Chapter's Specifications in three steps to avoid warping the cover.

34 The remainder of refitting is the reverse of removal. Refer to Section 9 for balancer refitting.

35 Add oil and coolant, start the engine and check for leaks.

11 Cylinder heads - removal and refitting

Refer to illustration 11.21

REMOVAL

1 Disconnect the negative battery cable at the battery.

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

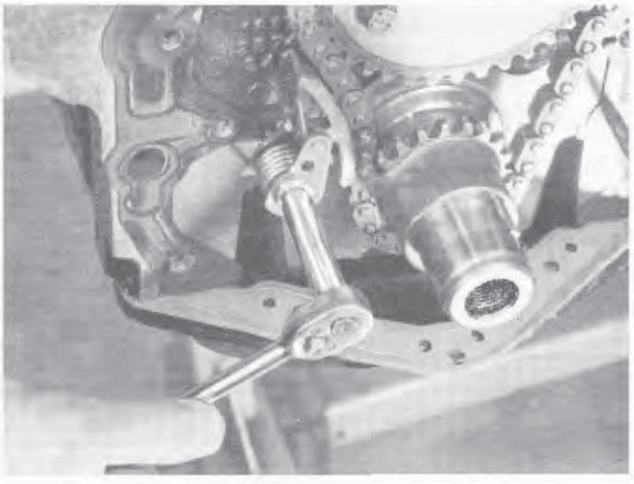
2 Disconnect the spark plug wires and remove the spark plugs (see Chapter 1). Be sure to label the plug wires to simplify refitting. Lay them out of the way.

3 Remove the valve covers (see Section 4).

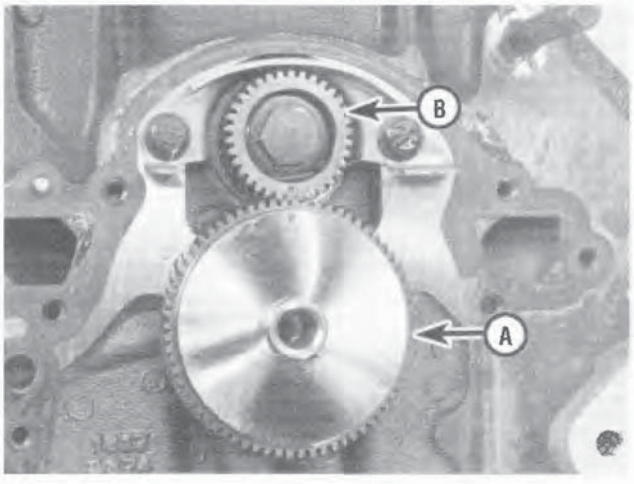
4 Remove the rocker arms and pushrods (see Section 5).

5 Remove the inlet manifold as described in Section 7.

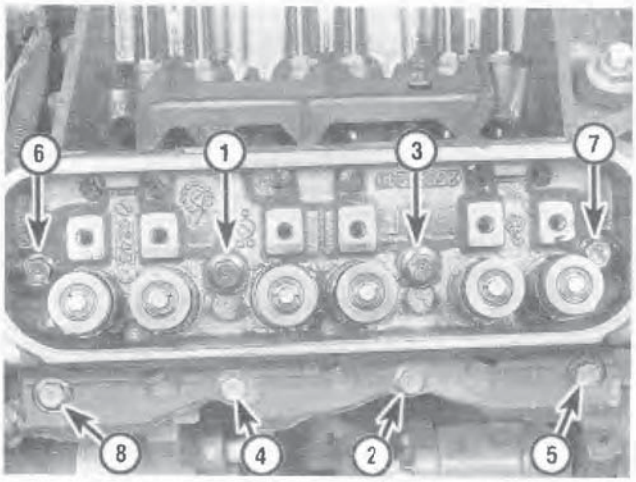
6 Disconnect all interfering wires, brackets and hoses from the cylinder head(s). Be sure to label them to simplify refitting.



10.22 Removing the timing chain damper (tensioner)



10.26 Align the mark on the balance shaft gear (B) with the mark on the drive gear (A)



11.21 Cylinder head bolt TIGHTENING sequence

7 Remove the dipstick. Remove the heat shield over the starter.

8 Detach the exhaust manifold(s) from the cylinder head(s) being removed (see Section 8).

9 Remove the ignition coil assembly if you are removing the left head.

10 Remove the serpentine belt tensioner assembly.

11 Loosen the head bolts in 1/4-turn increments until they can be removed by hand. Work from bolt-to-bolt in the reverse of the tightening sequence (see illustration 11.21).

12 Lift the head off the engine. If resistance is felt, don't prise between the head and block as damage to the mating surfaces will result. Recheck for head bolts that may have been overlooked, then use a hammer and block of wood to tap the head and break the gasket seal. Be careful because there are locating dowels in the block which position each head. As a last resort, prise each head up at the rear corner only and be careful not to damage anything. After removal, place the head on blocks of wood to prevent damage to the gasket surfaces.

13 Refer to Chapter 2, Part E, for cylinder head disassembly, inspection and valve service procedures.

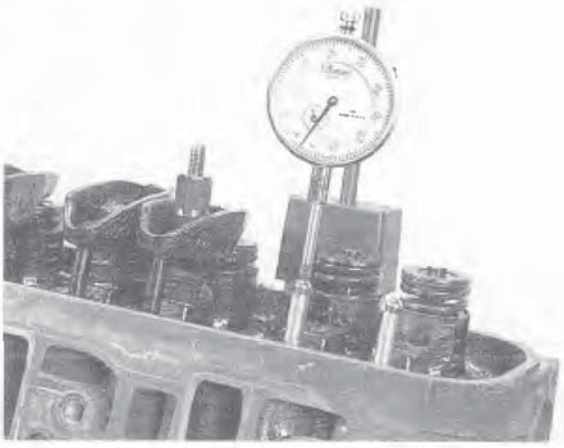
REFITTING

14 The mating surfaces of the cylinder heads and block must be perfectly clean when the heads are refitted.

15 Use a gasket scraper to remove all traces of carbon and old gasket material, then clean the mating surfaces with lacquer thinner or acetone. If there's oil on the mating surfaces when the heads are refitted, the gaskets may not seal correctly and leaks may develop. When working on the block, it's a good idea to cover the lifter valley and balancer shaft with shop rags to keep debris out of the engine. Use a shop rag or vacuum cleaner to remove any debris that falls into the cylinders.

16 Check the block and head mating surfaces for nicks, deep scratches and other damage. If damage is slight, it can be removed with a file; if it's excessive, machining may be the only alternative.

17 Use a tap of the correct size to clean up the threads in the head bolt holes. Dirt, corrosion, sealant and damaged threads will affect torque readings.



12.3 Position a dial indicator directly above the pushrod to measure camshaft lobe lift

18 Position the new gaskets over the dowel pins in the block. Most gaskets are marked TOP. VT series gaskets have arrows which must point to the front of the engine. There is also an "L" cut into the left gasket, The right gasket has a 5 mm hole. Make absolutely certain that your gaskets are correctly refitted before proceeding.

19 Carefully position the heads on the block without disturbing the gaskets.

20 Apply Loctite 242 or its equivalent to the threads of the bolt heads.

> ***Note:*** *All models have head bolts of two different lengths, the four longer bolts go on the upper row.*

21 Tighten the bolts as directed in this Chapter's Specifications in the sequence shown (see illustration). This must be done in three steps, following the sequence each time.

22 The remaining refitting steps are the reverse of removal.

23 Change the oil and filter (see Chapter 1).

12 Camshaft and lifters - removal, inspection and refitting

CAMSHAFT LOBE LIFT CHECK

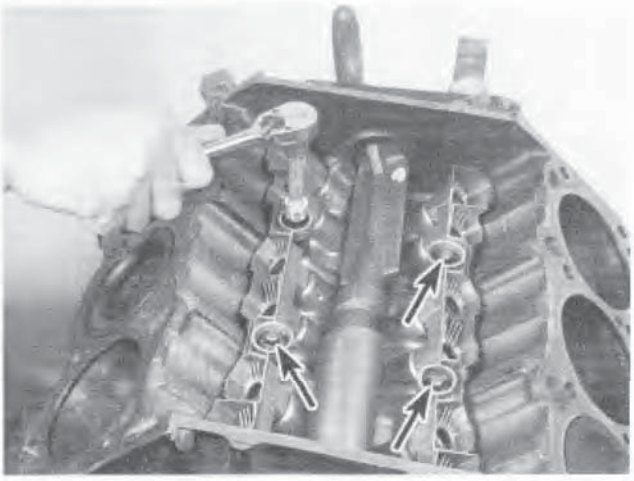
Refer to illustration 12.3

> ***Note:*** *A quick cam lobe lift check can be done simply by observing the rocker arm action with the valve covers removed and the engine cranked with the starter. If a lobe is seriously damaged, its rocker arm will have much less movement than the others.*

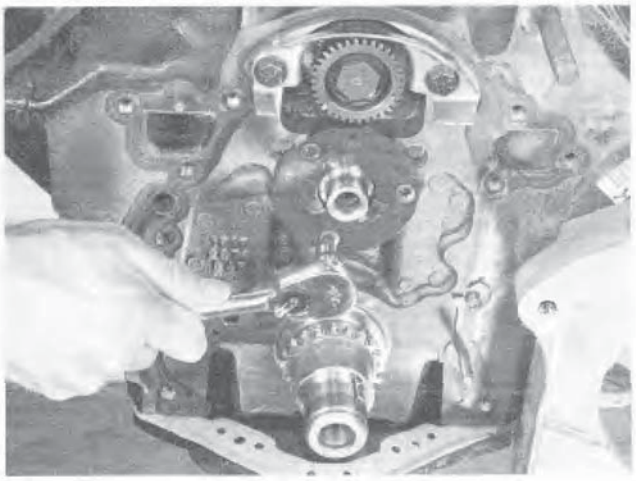
1 To determine the extent of cam lobe wear, the lobe lift should be checked prior to camshaft removal. Refer to Section 4 and remove the valve covers.

2 Remove the rocker arms. Refer to Section 5.

3 Beginning with the number one cylinder, mount a dial indicator on the engine and position the plunger against the top surface of the first pushrod (see illustration). Rotate the



12.13 The roller lifters are kept from turning by guides bolted to the sides of the lifter galley - remove the four bolts to take off the guides



12.19 With the balance shaft drive gear off the camshaft, remove the three Torx screws and take off the camshaft thrust plate

engine by hand if necessary until you are sure that the lifter is on the lowest part (heel) of the cam.

4 Zero the dial indicator, then very slowly turn the crankshaft in the normal direction of rotation until the indicator needle rises and then stops and begins to move in the opposite direction. The point at which it stops indicates approximate maximum cam lobe lift.

5 Record this figure for future reference.

6 Repeat the check for the remaining valves.

7 After the check is complete, compare the results to Specifications. If camshaft lobe lift is appreciably less than specified, cam lobe wear has occurred and a new camshaft should be fitted.

8 A noisy valve lifter can be isolated when the engine is idling. Hold a mechanic's stethoscope or a length of hose near the position of each valve while listening at the other end.

9 The most likely causes of noisy valve lifters are dirt trapped between the plunger and the lifter body or lack of oil flow, viscosity or pressure. Before condemning the lifters, we recommend checking the oil for fuel contamination, proper level, cleanliness and correct viscosity.

LIFTER REMOVAL

Refer to illustration 12.13

10 Remove the valve cover(s) as described in Section 4.

11 Remove the rocker arms, retainers and pushrods (see Section 5).

12 Remove the inlet manifold as described in Section 7.

13 Roller lifters are kept from turning by guides (see illustration), which must be removed to access the lifters.

14 There are several ways to extract the lifters from the bores. A special tool designed to grip and remove lifters is manufactured by many tool companies and is widely available, but it is not required in every case. On newer engines without a lot of varnish buildup, the lifters can often be removed with a small magnet or with your fingers. A machinist's scribe with a bent end can be used to pull the lifters out by positioning the point under the retainer ring in the top of each lifter.

Caution: *Don't use pliers to remove the lifters unless you intend to renew them with new ones. The pliers will damage the precision machined and hardened lifters, rendering them useless.*

15 Before removing the lifters, arrange to store them in a clearly labelled box to ensure that they're refitted in their original locations. Remove the lifters and store them where they won't get dirty.

CAMSHAFT REMOVAL

Refer to illustration 12.19

16 To allow room for camshaft removal, the radiator and air conditioning condenser must be removed (see Chapter 3).

Warning: *The air conditioning system is under high pressure. DO NOT loosen any fittings or remove any components until after the system has been discharged. Air conditioning refrigerant should be properly discharged into an approved recovery container at a dealership service department or an automotive air conditioning repair facility. Always wear eye protection when disconnecting air conditioning system fittings.*

17 Remove the timing chain front cover, the timing chain and camshaft sprocket (see Section 10). Remove the inlet manifold (see Section 7).

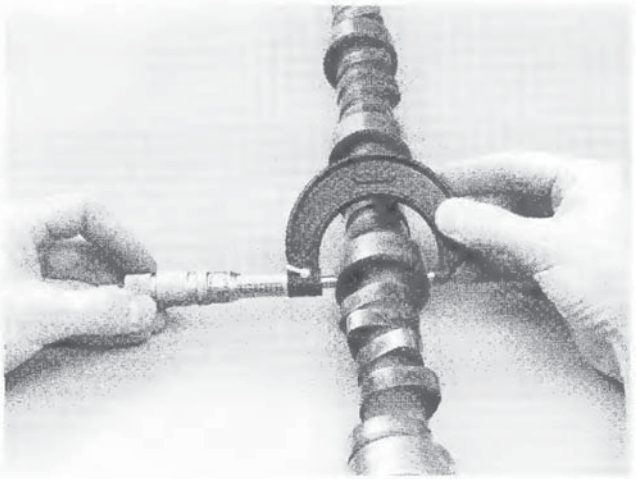
18 Pull the balance shaft drive gear from the front of the camshaft.

19 Remove the camshaft thrust plate bolts and the thrust plate (see illustration).

20 Carefully pull the camshaft out. It may be helpful to screw a long bolt into the front of the camshaft to act as a handle. Support the cam near the block so the lobes do not nick or gouge the bearings as the cam is withdrawn.

Caution: *All the camshaft journals are the same size, so the camshaft must be withdrawn straight out to prevent damage to the bearings or journals.*

12.23 The roller must turn freely - check for wear and excessive play as well



12.27 Check the diameter of each camshaft bearing journal to pinpoint excessive wear and out-of-round conditions

INSPECTION

Refer to illustrations 12.23 and 12.27

21 Parts for valve lifters are not available separately. The work required to remove them from the engine again if repair is unsuccessful outweighs any potential savings from repairing them.

22 Clean the lifters with solvent and dry them thoroughly without mixing them up.

23 Check the rollers carefully for wear and damage and make sure they turn freely without excessive play (see illustration). If the lifter walls are damaged or worn (which is not very likely), inspect the lifter bores in the engine block as well. If the pushrod seats are worn, check the pushrod ends.

24 Used roller lifters can be refitted with a new camshaft (provided the lifters are in good condition) and the original camshaft can be used if new lifters are fitted (provided the camshaft is in good condition).

25 When refitting used lifters, make sure they're refitted in their original bores. Soak new lifters in oil to remove trapped air. Coat all lifter rollers with moly-base grease or engine assembly lube prior to refitting.

26 After the camshaft has been removed from the engine, cleaned with solvent and dried, inspect the bearing journals for uneven wear, pitting and evidence of seizure. If the journals are damaged, the bearing inserts in the block are probably damaged as well. Both the camshaft and bearings will have to be renewed. Renewal of the camshaft bearings requires special tools and techniques which place it beyond the scope of the home mechanic. The block will have to be removed from the vehicle and taken to an automotive machine shop for this procedure.

27 Measure the bearing journals with a micrometer to determine if they are excessively worn or out-of-round (see illustration) and compare your figures to this Chapter's Specifications.

28 Check the camshaft lobes for heat discolouration, score marks, chipped areas, excessive pitting and uneven wear. If the lobes are in good condition and if the lobe lift measurements are as specified, the camshaft can be reused.

REFITTING

Refer to illustration 12.29

29 Lubricate the camshaft bearing journals and cam lobes with clean oil or special camshaft assembly lube (see illustration).

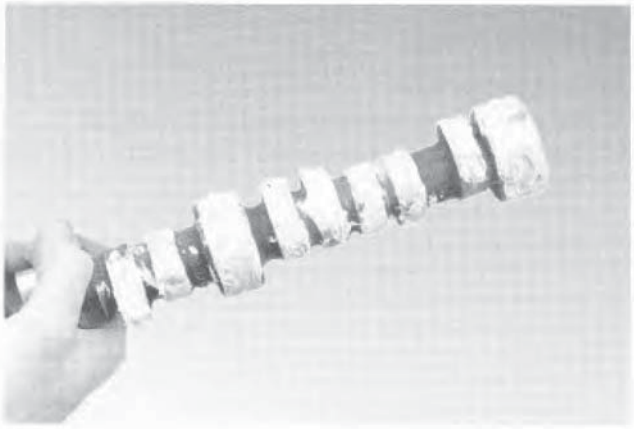
30 Slide the camshaft into the engine. Support the cam near the block and be careful not to scrape or nick the bearings.

31 Refit the camshaft thrust plate on all later engines and slip the balance shaft drive gear over the cam, aligning it with the keyway and with drive gear and driven gear timing marks aligned.

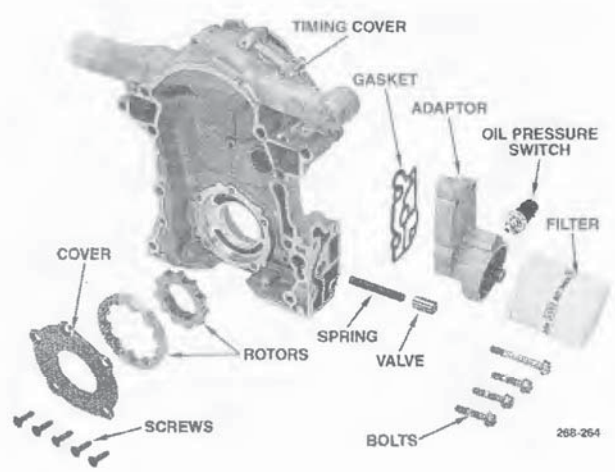
> **Note:** *The camshaft thrust plate is marked TOP - this marking must be at the top and facing the front. Use Loctite 242 on the threads of the thrust plate bolts.*

32 Refer to Section 10 and refit the timing chain and sprockets, with the timing marks aligned.

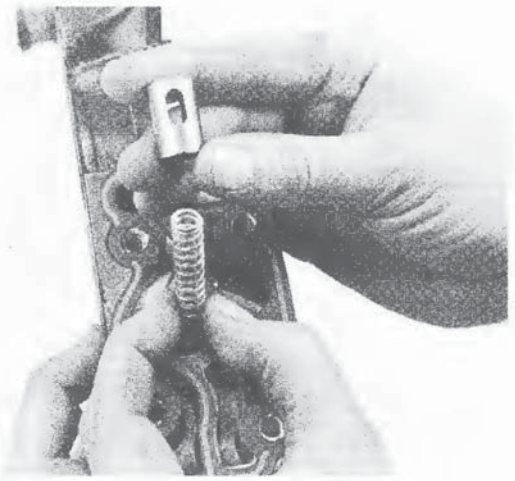
> **Note:** *If the engine has accumulated enough kilometres for the camshaft/lifters to have been renewed, this is the time to also renew the timing chain and sprocket set.*



12.29 Be sure to apply moly-base grease or engine assembly lube to the cam lobes and bearing journals before refitting the camshaft



13.3 The oil filter adapter and pressure regulator - exploded view



13.4 Remove the pressure regulator valve and spring, then check the valve for wear and damage

33 Lubricate the lifters with clean engine oil and refit them in the block. If the original lifters are being refitted, be sure to return them to their original locations.

34 The remaining refitting steps are the reverse of removal.

35 Before starting and running the engine, change the oil and fit a new oil filter (see Chapter 1).

36 Run the engine and check for leaks.

13 Oil filter adapter and pressure regulator valve - removal and refitting

Refer to illustrations 13.3 and 13.4

1 Remove the oil filter (see Chapter 1).

2 Disconnect the wiring at the oil pressure sender. It may be necessary to remove the entire sender.

3 Remove the bolts holding the oil filter adapter to the timing chain cover (see illustration). The cover is spring loaded, so remove the bolts while keeping force on the cover, then release the spring force carefully.

4 Remove the pressure regulator valve and spring (see illustration). Use a gasket scraper to remove all traces of the old gasket.

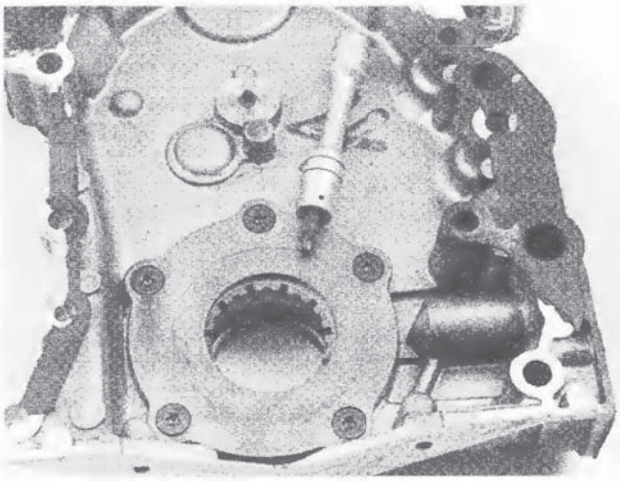
5 Clean all parts with solvent and dry them with compressed air (if available).

***Warning:** Wear eye protection. Check for wear, score marks and valve binding.*

6 Refitting is the reverse of removal. Apply Loctite 242 to the bolt that goes beneath the oil filter. Be sure to use a new gasket.

7 Tighten the bolts to the torque listed in this Chapter's Specifications.

8 Run the engine and check for oil leaks.



14.4 The oil pump cover is attached to the inside of the front cover - a T-30 Torx driver is required for removal of the screws

14 Oil pump - removal, inspection and refitting

REMOVAL

Refer to illustration 14.4

1 Remove the engine front cover (see Section 10).

2 Remove the oil filter (see Chapter 1).

3 Remove the oil filter adapter, pressure regulator valve and spring (see Section 13).

4 Remove the oil pump cover bolts (see illustration).

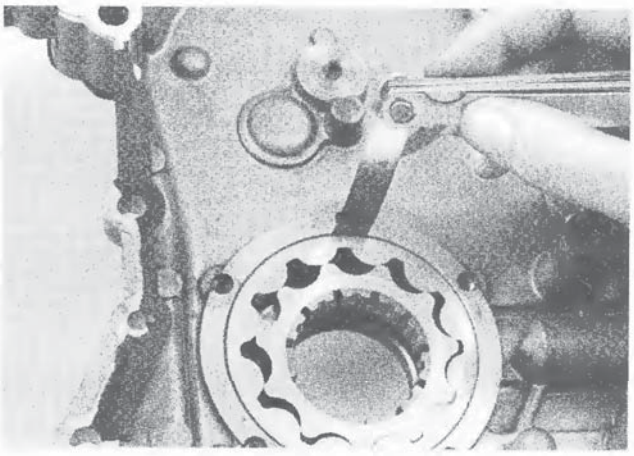
5 Lift out the cover and oil pump gears as an assembly.

INSPECTION

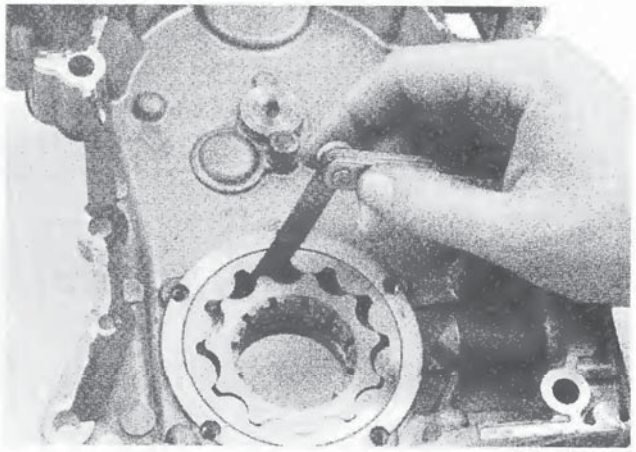
Refer to illustrations 14.10 and 14.11

6 Clean the parts with solvent and dry them with compressed air (if available).

***Warning:** Wear eye protection!*



14.10 Measuring the outer gear-to-housing clearance with a feeler gauge



14.11 Measuring the inner gear-to-outer gear clearance

7 Inspect all components for wear and score marks. Renew any worn out or damaged parts.
8 Refer to Section 13 for pressure regulator valve information.
9 Refit the gears in the timing chain cover.
10 Measure the outer gear-to-housing clearance with a feeler gauge (see illustration).
11 Measure the inner gear-to-outer gear clearance at several points (see illustration).
12 Use a dial indicator or straightedge and feeler gauges to measure the gear end clearance (distance from the gear to the gasket surface of the cover). Feeler gauges can be inserted under a straightedge (between the straightedge and the gears) held across the cover to determine the existing clearance.
13 Check for pump cover warpage by laying a precision straightedge across the cover and trying to slip a feeler gauge between the cover and straightedge.
14 Compare the measurements to this Chapter's Specifications. Renew all worn or damaged components with new ones.

REFITTING

15 Remove the gears and pack the pump cavity with petroleum jelly.
16 Refit the gears - make sure petroleum jelly is forced into every cavity. Failure to do so could cause the pump to lose its prime when the engine is started, causing damage from lack of oil pressure.
17 Fit the pump cover. Tighten the screws to the torque listed in this Chapter's Specifications.
18 Refit the pressure regulator spring and valve.
19 Refit the front cover.
20 Refit the oil filter adapter and filter and check the oil level. Start and run the engine and check for correct oil pressure, then look carefully for oil leaks at the timing chain cover.

15 Sump and beaming brace - removal and refitting

Refer to illustrations 15.15 and 15.17

1 Disconnect the cable from the negative battery terminal.

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

2 Raise the vehicle and support it securely on jackstands. Drain the engine oil and renew the oil filter (refer to Chapter 1 if necessary).

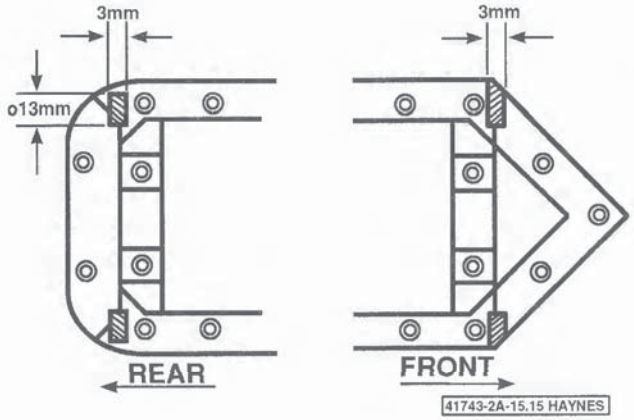
BEAMING BRACE REMOVAL AND REFITTING

3 Remove the bolts that secure the brace to the transmission and the engine sump.
4 Remove the brace.
5 When refitting the brace, torque the bolts to the automatic transmission first. Follow the torque recommendations in this Chapter.
6 On vehicles equipped with an automatic transmission, refit the bolts into the torque converter housing and tighten them first.
7 The rest of the refitting is the reverse of removal. Tighten all fasteners to the figures listed in the Specifications in this Chapter.

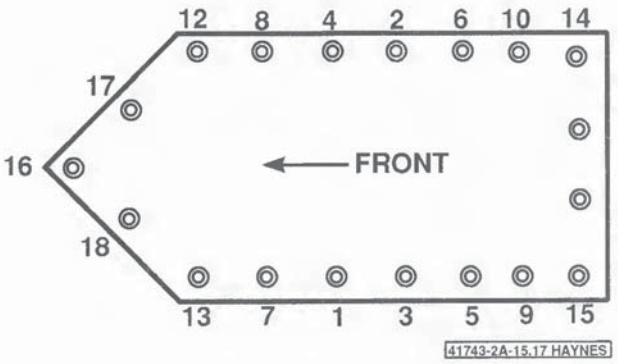
SUMP REMOVAL AND REFITTING

Warning: *On supercharged models, the front crossmember must be removed to provide sufficient clearance for sump removal. On refitting the crossmember must be centered exactly as originally refitted or poor steering performance will result. Some special tools and techniques will be required to perform this procedure. The engine must be supported from above before removing the crossmember and remain supported the entire time the crossmember is removed. Do not attempt this procedure unless the necessary tools and equipment are available. The following procedure applies to non-supercharged models. For supercharged models, refer to sump removal and refitting in Chapter 2 Part C for crossmember removal and refitting procedures.*

8 Remove the beaming brace (refer to Step 3).
9 Disconnect any wiring harnesses or lines that are attached to the sump.



15.15 On 1999 series II engines, Permatex "The Right Stuff" must be applied in a 1 mm thickness to these areas on the bottom of the engine block to prevent leaks



15.17 Sump bolt tightening sequence

10 Remove the engine mount nut from each side of the engine.

11 Using a floor jack with a piece of wood on the head, raise the engine from beneath the sump approximately 40 mm. Insert 40 mm spacers under the engine mount and then remove the jack.

12 Remove the sump mounting bolts and carefully separate the sump from the block. Don't prise between the block and the pan or damage to the sealing surfaces may result and oil leaks may develop. Instead, tap the pan with a soft-face hammer to break the gasket seal. Twist the pan while lowering the rear of the pan.

13 Clean the pan with solvent and remove all old sealant and gasket material from the block and pan mating surfaces. Clean the mating surfaces with lacquer thinner or acetone and make sure the bolt holes in the block are clear. Check the sump flange for distortion, particularly around the bolt holes.

14 Always use a new gasket whenever the sump is refitted. The dimples on the new seal will engage in the holes in the sump.

15 On 1997 and 1998 models, apply a very thin bead of Permatex "The Right Stuff" sealer or its equivalent 6 mm wide and 0.3 mm thick to the block. Do not apply this sealer any thicker than 0.3 mm. Do not apply sealer to the area where the front cover and the rear seal retainer contact the block. On 1999 models, apply a bead of "The Right Stuff" sealer to the joints of the front cover and the rear oil seal housing (see illustration). These applications of sealer should be 3 mm wide as measured across the joints and 1 mm in thickness.

Note: *In order to achieve a 1 mm thickness, place 1 mm thick tape along the edges of the areas to be filled with sealer. Remove the tape after leveling the sealer between the tape pieces with a putty knife.*

Do not allow sealer to touch the areas adjacent to the rear main bearing cap.

16 Place the oil pan in position on the block and refit the bolts.

Note: *Apply Loctite 243 to the bolts before fitting them. In order to avoid a wiping motion when refitting the pan, use two temporary positioning studs to guide the oil pan into place.*

17 After the bolts are fitted, tighten them to the torque listed in this Chapter's Specifications within five minutes. Starting at the center, follow the correct sequence and work up to the final torque in three steps (see illustration).

18 The remaining steps are the reverse of the removal procedure.

19 Refill the engine with oil. Run the engine until normal operating temperature is reached and check for leaks.

16 Oil pump pick-up tube and screen assembly - removal and refitting

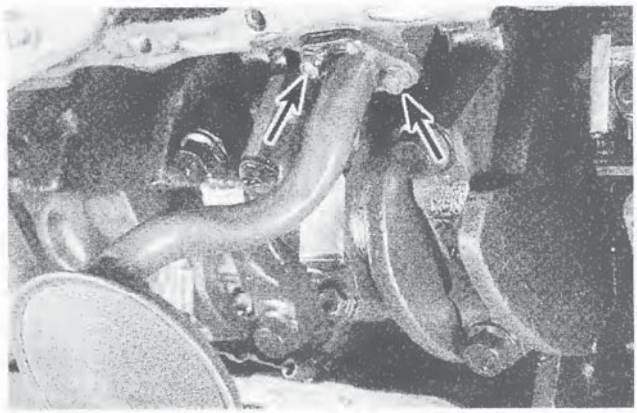
Refer to illustration 16.2

1 Remove the sump (see Section 15).

2 Unbolt the oil pump pick-up tube and screen assembly and detach it from the engine (see illustration).

3 Clean the screen and housing assembly with solvent and dry it with compressed air, if available.

Warning: *Wear eye protection.*



16.2 Remove the bolts (arrows) and lower the pick-up tube and screen assembly

4 If the oil screen is damaged or has metal chips in it, renew it. An abundance of metal chips indicates a major engine problem which must be corrected.
5 Clean the mounting holes in the block with acetone and compressed air. Apply Loctite 242 to the threads of the bolts. Make sure the mating surfaces of the pipe flange and the engine block are clean and free of nicks and refit the screen assembly with a new O-ring.
6 Refit the sump (see Section 15).
7 Be sure to refill the engine with oil before starting it.

17 Flywheel/driveplate - removal and refitting

1 Disconnect the negative battery cable.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

2 Refer to Chapter 7 and remove the transmission.
3 Remove the clutch on manual transmission vehicles (refer to Chapter 8). Remove the torque converter from vehicles equipped with an automatic transmission. Mark the position of the torque converter to the driveplate with a dab of paint.
4 Use a flywheel holder or a large screwdriver to lock the flywheel as you remove the bolts.
5 Remove the flywheel/driveplate.

> ***Caution:*** *The manual transmission flywheel is heavy. Use care and support it as you remove the last bolt. Use gloves or a rag to hold it.*

6 Clean the flywheel thoroughly and inspect it for cracks, grooves, burned areas and score marks. Check for broken or worn ring gear teeth. Refer to Chapter 8 for more information on the flywheel.
7 Do not interchange longer flywheel bolts with the shorter driveplate bolts. The driveplate bolts are 16 mm long; the dual mass flywheel bolts are 45 mm long. Discard the used bolts and renew them with new ones.
8 Apply Loctite 242 to the threads of the bolts. Torque them to the Specification in this Chapter.
9 Check the runout of the automatic transmission driveplate using a dial indicator. Refer to the Specifications in this Chapter for the runout limit. A slight amount of runout can be repaired by careful tapping with a rubber mallet. The driveplate will have to be renewed if the runout cannot be corrected with a rubber mallet.
10 Refitting is the reverse of removal.

18 Rear main oil seal - renewal

Refer to illustration 18.3

1 Remove the transmission as described in the relevant transmission Chapter.
2 Remove the flywheel or driveplate as described in Section 17.
3 Using a screwdriver, lever the seal from the oil seal housing ensuring that a thin piece of shim brass is positioned between the screwdriver and the crankshaft to protect the crankshaft surface **(see illustration)**. Use care not to damage the oil seal housing.
4 Check the oil seal housing for burrs and damage. Small burrs may be removed with a fine oil stone.
5 Check the seal contact surface on the crankshaft for grooves or damage and repair or renew the crankshaft as necessary.
6 Apply clean engine oil to the inner and outer sealing surfaces on the new seal.
7 Using a suitable size tube or mandrel, install the seal squarely into the oil seal housing, until there is a distance of 2.5 - 3.0 mm from the rear face of the seal to the rear face of the housing. Ensure that the lip with the spring is facing towards the front of the engine.
8 Install the flywheel or driveplate as described in Section 17.
9 Install the transmission as described in the relevant transmission Chapter.

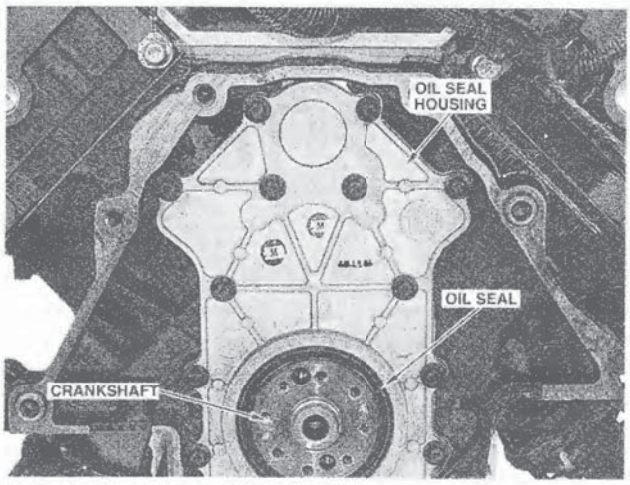
19 Rear main oil seal housing - removal and refitting

TO REMOVE

Refer to illustration 19.6

1 Drain the cooling system as described in Chapter 1.
2 Remove the transmission from the vehicle, as described in the relevant transmission chapter.
3 On manual transmission models, remove the clutch assembly as described in Chapter 8.
4 Remove the flywheel/driveplate as described in Section 17.
5 Remove and discard the bolts retaining the housing to the cylinder block.

> ***Note:*** *The retaining bolts are of the stretch type and can only be used once.*



18.3 Location of the rear crankshaft oil seal.

6 Using a thin screwdriver, carefully prise the housing away from the cylinder block and withdraw the housing (see illustration).

7 If necessary, support the housing on timber blocks and remove the rear crankshaft oil seal using a hammer and punch.

REFITTING

Refer to illustrations 19.11 and 19.17

8 Clean the gasket surfaces of the cylinder block and the housing, ensuring that they are perfectly clean and free from burrs or traces of old gasket.

> ***Note:*** *Ensure that no pieces of gasket are allowed to enter the coolant passages or oilways. Using a clean cloth cover the sump opening, to prevent gasket material entering the sump.*

9 Ensure that the sump seal is in serviceable condition. If the condition of the sump seal is suspect, remove the sump and renew the seal as previously described.

10 Inspect the condition of the plastic locators. Discard if broken or brittle.

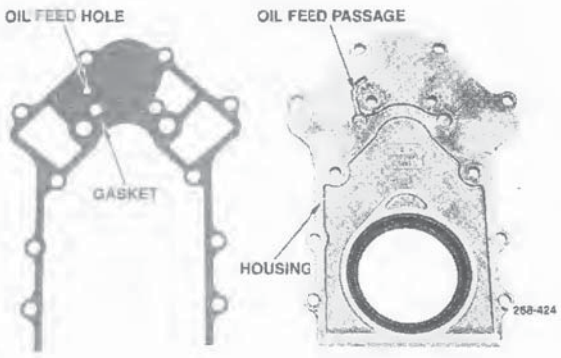
> ***Note:*** *The locators are only used during production to retain the bolts in place, and if damaged, they can be discarded as no replacement is available.*

11 If removed, support the oil seal housing on timber blocks and using a mandrel, install the seal squarely into the recess until there is a distance of 2.5 - 3.0 mm from the rear face of the seal to the rear face of the oil seal housing. Ensure that the lip with the spring is facing towards the front of the engine (see illustration).

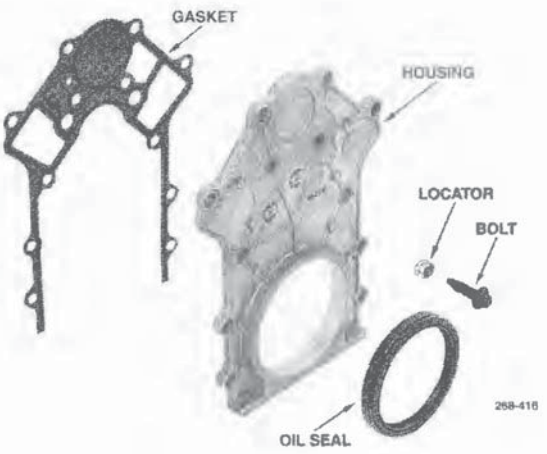
12 Ensure that the seal running surface of the crankshaft is in good condition, i.e., no groove or scoring. Refer the crankshaft to a specialist or renew if necessary.

13 Using a vernier calipers, check the thickness of the housing at the thinnest point, facing the sump. The dimension should be between 7.24 - 7.29 mm. Renew the housing if dimension is outside the specification.

14 Apply a 2 - 3 mm bead of Permatex Ultra Blue or equivalent sealant to the cylinder block to sump joint and to the sump seal outer surface. The sealant will act as a lubricant on the sump seal, while installing the housing, so it is essential to spread the sealant evenly onto the sump seal.



19.11 When installing the rear crankshaft oil seal housing to the cylkinder block, ensure that the oil feed hole aligns with the oil feed passage on the housing.



19.6 Rear crankshaft oil seal housing and associated components

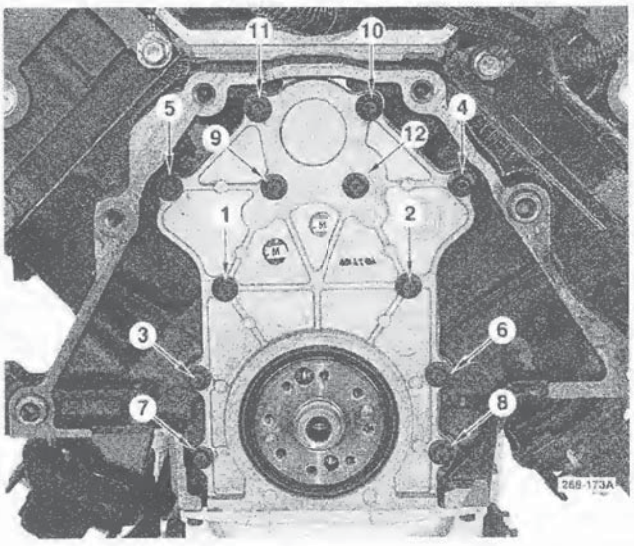
15 Place the housing gasket on the cylinder block, ensuring that the sealant bead on the gasket faces the cylinder block and that all holes are aligned.

16 If applicable, place the locators onto the retaining bolts, and install the housing to the cylinder block. Do not tighten the retaining bolts at this stage.

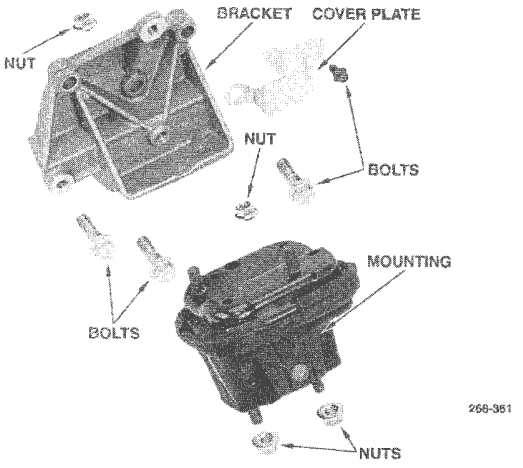
17 Gently move the housing around and allow the seal to centralise the housing (see illustration). Tighten the retaining bolts to the specified torque in the sequence shown in the illustration.

18 Fill the cooling system as described in Chapter 1.

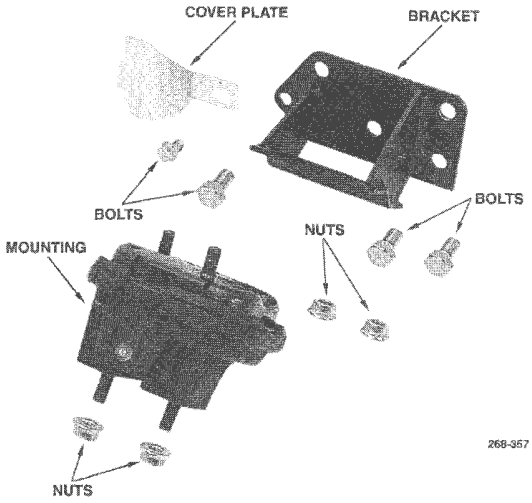
> ***Caution:*** *If the cooling system is not filled as described, engine overheating may result.*



19.17 Rear crankshaft oi seal housing tightening sequence



20.3a Left hand side engine mounting componnents.



20.3b Right hand side engine mounting components

20 Engine mounts - check and renewal

CHECK

1 Engine mountings that are oil soaked should be renewed and the cause of the oil leak rectified to ensure a normal working life for the mounting concerned.

RENEWAL

Refer to illustrations 20.3a and 20.3b

2 Disconnect the negative battery terminal and raise the front of the vehicle and support it on chassis stands.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

3 Remove the nuts retaining the front mountings to the cross-member (see illustrations).

4 Raise the engine slightly using a floor jack or overhead lifting tackle.

> ***Note:*** *If a floor jack is used to raise the engine, ensure that a piece of timber is installed between the sump and the head of the jack. If using overhead lifting tackle, refer to the engine removal heading for the procedure to make engine lifting brackets.*

5 When removing the left hand front mounting, proceed as follows:

a) Release the clamp securing the inlet duct hose to the throttle body. Release the air cleaner housing clips and disconnect the wiring connectors from the air flow sensor and the air temperature sensor. Remove the duct, the air flow sensor and the air cleaner housing from the vehicle.

b) On air conditioned models, remove the engine drive belt from the pulleys, using a suitable ring spanner to rotate the tensioner pulley away from the belt.

c) Remove the air conditioning compressor retaining bolts and secure the compressor away from the engine using a piece of rope or wire.

Ensure that excessive strain is not placed on the refrigerant pipes and hoses. Do not disconnect the pipes or hoses as escaping refrigerant may cause eye injury and frostbite and will necessitate regassing of the system.

6 If necessary, remove the bolt retaining the knock sensor cover plate. Remove the engine bracket retaining bolts and manoeuvre the engine brackets and mountings from the vehicle.

7 If necessary, remove the nuts retaining the mountings and separate the mountings from the brackets.

8 If the engine bracket was removed from the engine install the bracket and the knock sensor cover plate. Tighten the bolts securely.

9 When the full weight of the engine is on the mounting tighten all nuts securely.

10 Where applicable, rotate the drivebelt tensioner and install the engine drivebelt. If necessary, refer to the illustrations in Chapter 1, Section 25.

Chapter 2
Engine

Part B. 3.6 litre Alloytec V6 engine

Contents

Specifications

General

Displacement	3.6 litre (3,565 cm³)
Bore and stroke	94.0 x 85.6 mm
Cylinder numbers (front-to-rear)	
Left side	2-4-6
Right (drivers) side	1-3-5
Firing order	1-2-3-4-5-6

Camshaft

Journal diameter	
Front cylinder	34.936 to 34.960 mm
Middle and rear cylinders	26.936 to 26.960 mm
Camshaft endplay	0.045 to 0.215 mm

Lobe lift

Valve lift	10.8 mm
Lobe height	
175 kW engine	
Intake	6.2 mm
Exhaust	6.6 mm
190 kW engine	
Intake	6.5 mm
Exhaust	6.6 mm

Torque specifications*	Nm (unless otherwise indicated)
Camshaft bearing cap bolts	10
Camshaft sprocket bolts	35
Crankshaft balancer bolt	
Step one (use NEW bolt)	100
Step two (use NEW bolt)	Turn an additional 150 degrees
Cylinder head bolts (in sequence)	
M8 bolts	
Step one	15
Step two	Turn an additional 60 degrees
M11 bolts	
Step one	45
Step two	Turn an additional 120 degrees
Dipstick tube bolt	10
Engine mount bracket to engine block bolts	40 to 60
Engine mount nuts	70 to 90
Engine dress cover nuts	10
Exhaust manifold bolts	20
Exhaust manifold heat shield bolt	10
Exhaust pipe flange nuts	18 to 35
Flywheel/driveplate bolts	
Step one	30
Step two	Turn an additional 45 degrees
Fuel rail	10
Inlet manifold bolts	23
Sump baffle bolts	10
Sump drain plug	25
Sump to rear main oil seal housing bolts	10
Sump bolts	23
Oil pickup pipe bolts	10
Oil pump mounting bolts	23
Timing chain cover bolts	
To 2006 models	23
From 2006 models	
Step one	20
Step two	Turn an additional 60 degrees
Timing chain guide bolts	24
Timing chain idler sprocket bolts	65
Timing chain tensioner bolts	23
Valve cover bolts	10

**Note: Refer to Part E for additional specifications.*

1 General information

Warning: *The models covered by this manual are equipped with airbags. Always disable the airbag system before working in the vicinity of the impact sensors, steering column or instrument panel to avoid the possibility of accidental deployment of the airbag(s), which could cause personal injury (see Chapter 12).*

Caution: *On models equipped with a Anti-theft audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery.*

This Part of Chapter 2 is devoted to in-vehicle repair procedures for the Alloytec 3.6L V6 engine. All information concerning engine removal and refitting and engine block and cylinder head overhaul on this engine can be found in Part E of this Chapter.

Since the repair procedures included in this Part are based on the assumption the engine is still in the vehicle, if they are being used during a complete engine overhaul (with the engine already removed from the vehicle and on a stand) many of the Steps included here will not apply.

The Specifications included in this Part of Chapter 2 apply only to the procedures found here. The specifications necessary for rebuilding the block and cylinder heads are included in Part E.

The engine utilizes an aluminium block with cast-iron sleeves. The six cylinders are arranged in a "V" shape at a 60-degree angle between the two banks. The cylinder heads utilize a twin overhead camshaft arrangement with four valves per cylinder. On the 190 kW engine, variable cam timing is used via an adjustable camshaft drive sprocket controlled by the engine control system. The engine uses aluminium cylinder heads with powdered metal guides and valve seats. Hydraulic lifters negate the need for valve adjustments and roller rocker arms actuate the valves. The oil pump is mounted at the front of the engine behind the timing chain cover and is driven by the crankshaft.

2 Repair operations possible with the engine in the vehicle

Many major repair operations can be accomplished without removing the engine from the vehicle.

Clean the engine compartment and the exterior of the engine with some type of pressure washer before any work is done. A clean engine will make the job easier and will help keep dirt out of the internal areas of the engine.

Depending on the components involved, it may be a good idea to remove the bonnet to improve access to the engine as repairs are performed (refer to Chapter 11 if necessary).

If oil or coolant leaks develop, indicating a need for gasket or seal renewal, the repairs can generally be made with the engine in the vehicle. The sump gasket, the cylinder head gaskets, inlet and exhaust manifold gaskets, timing chain cover gaskets and the crankshaft oil seals are all accessible with the engine in place.

Exterior engine components, such as the water pump, the starter motor, the alternator, the power steering pump and the fuel injection components, as well as the inlet and exhaust manifolds, can be removed for repair with the engine in place.

Since the cylinder heads can be removed without removing the engine, valve component servicing can also be accomplished with the engine in the vehicle.

Renewal of, repairs to or inspection of the timing chain and sprockets and the oil pump are all possible with the engine in place.

In extreme cases caused by a lack of necessary equipment, repair or renewal of piston rings, pistons, connecting rods and rod bearings is possible with the engine in the vehicle. However, this practice is not recommended because of the cleaning and preparation work that must be done to the components involved.

3 Top Dead Centre (TDC) for number one piston - locating

1 Top Dead Centre (TDC) is the highest point in the cylinder that each piston reaches as it travels up the cylinder bore. Each piston reaches TDC on the compression stroke and again on the exhaust stroke, but TDC generally refers to piston position on the compression stroke.

2 Positioning the piston(s) at TDC is an essential part of many procedures such as timing chain/sprocket removal.

3 Before beginning this procedure, be sure to place the transmission in Neutral and apply the parking brake or block the rear wheels. Also, disable the ignition system by disconnecting the primary electrical connectors at the ignition coil packs, then remove the spark plugs (see Chapter 1).

4 In order to bring any piston to TDC, the crankshaft must be turned using one of the methods outlined below. When looking at the front of the engine, normal crankshaft rotation is clockwise.

a *The preferred method is to turn the crankshaft with a socket and ratchet attached to the bolt threaded into the front of the crankshaft. Apply pressure on the bolt in a clockwise direction only. Never turn the bolt anti-clockwise.*

b *A remote starter switch, which may save some time, can also be used. Follow the instructions included with the switch. Once the piston is close to TDC, use a socket and ratchet as described in the previous paragraph.*

c *If an assistant is available to turn the ignition switch to the Start position in short bursts, you can get the piston close to TDC without a remote starter switch. Make sure your assistant is out of the vehicle, away from the ignition switch, then use a socket and ratchet as described in Paragraph (a) to complete the procedure.*

5 Place your finger partially over the number one spark plug hole and rotate the crankshaft using one of the methods described above until air pressure is felt at the No 1 cylinder spark plug hole. Air pressure at the spark plug hole indicates that the cylinder has started the compression stroke. Once the compression stroke has begun, TDC for the number one cylinder is obtained when the piston reaches the top of the cylinder on the compression stroke.

6 To bring the piston to the top of the cylinder, insert a long screwdriver into the number one spark plug hole until it touches the top of the piston.

Note: *Make sure to wrap the tip of the screwdriver with tape to avoid scratching the top of the piston and the cylinder walls.*

Use the screwdriver (as a feeler gauge) to tell where the top of the piston is located in the cylinder while slowly rotating the crankshaft (see illustration). As the piston rises the screwdriver will be pushed out. The point at which the screwdriver stops moving outward is TDC.

Note: *Always hold the screwdriver upright while the engine is being rotated so that the screwdriver will not get wedged as the piston travels upward.*

7 If you go past TDC, rotate the crankshaft anti-clockwise until the piston is approximately 20 mm below TDC, then slowly rotate the crankshaft clockwise again until TDC is reached.

8 After the number one piston has been positioned at TDC on the compression stroke, TDC for any of the remaining pistons can be located by repeating the procedure described above and following the firing order.

4 Valve covers - removal and refitting

Refer to illustrations 4.4, 4.7, 4.9

REMOVAL

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the front suspension brace from the vehicle (see Chapter 10).

3 Remove the engine covers and the plenum (see Section 7).

4 Disconnect the canister purge solenoid wiring and hoses. Also disconnect the necessary wiring to allow the wiring harnesses connected to the rocker covers to be positioned clear of the work area (see illustration). Release the wiring harness plastic sleeves from alongside the rocker covers and in front of the engine and position the wiring clear of the work area.

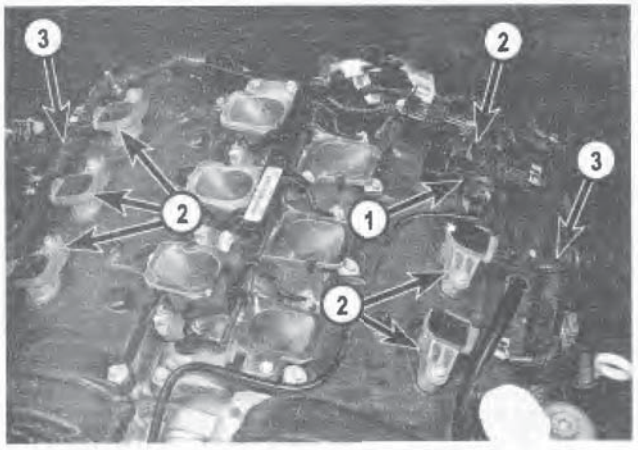
5 Remove the inlet manifold (see Section 7).

6 Remove the ignition coils from the valve cover (see Chapter 5).

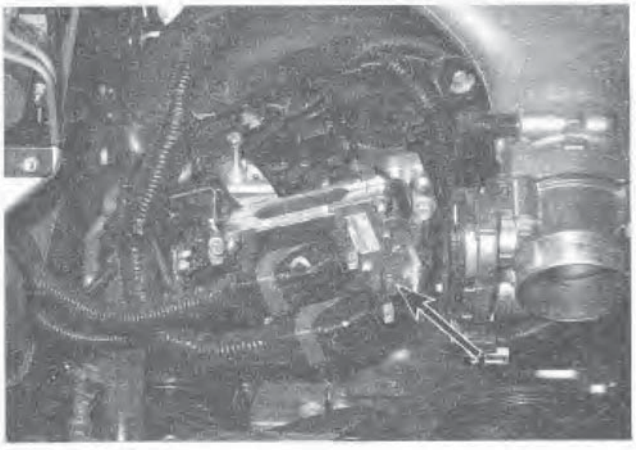
Right side

7 Disconnect the wiring from the ECM (see illustration).

8 Remove the valve cover bolts, then detach the cover from the cylinder head.

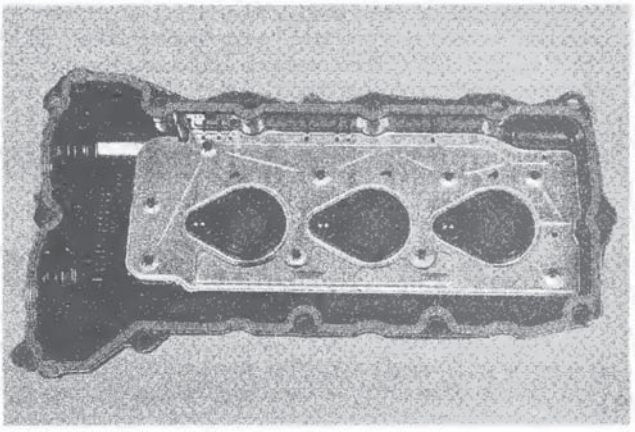


4.4 Disconnect the canister purge solenoid (1) wiring and hoses, the wiring from the ignition coils (2) and the wiring harnesses from the rocker covers (3)



4.7 Slide the grey levers across to disconnect the ECM connectors from the ECM

4.9 Engine dress cover brackets



4.14 Position the new gasket in the valve cover lip

> ***Note:*** *If the cover is stuck to the cylinder head, bump one end with a block of wood and a hammer to jar it loose. If that doesn't work, try to slip a flexible putty knife between the cylinder head and cover to break the gasket seal. Don't prise at the cover-to-head joint or damage to the sealing surfaces may occur (leading to oil leaks in the future).*

Left side

9 Remove the brackets for the engine dress cover (see illustration).

10 Remove the valve cover bolts, then detach the cover from the cylinder head.

> ***Note:*** *If the cover is stuck to the cylinder head, bump one end with a block of wood and a hammer to jar it loose. If that doesn't work, try to slip a flexible putty knife between the cylinder head and cover to break the gasket seal. Don't prise at the cover-to-head joint or damage to the sealing surfaces may occur (leading to oil leaks in the future).*

REFITTING

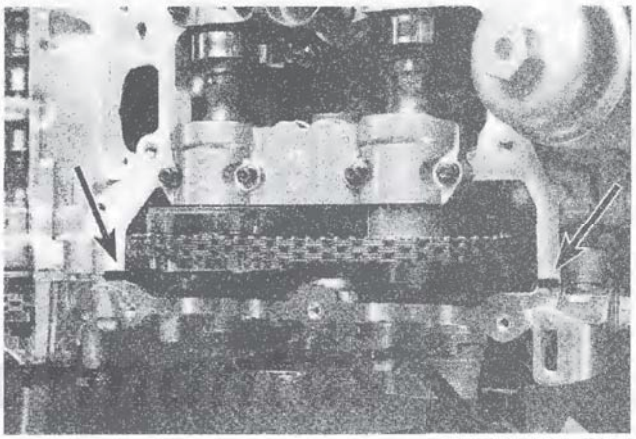
Refer to illustration 4.14 and 4.15

11 The mating surfaces of each cylinder head and valve cover must be perfectly clean when the covers are refitted. Use a gasket scraper to remove all traces of sealant and old gasket material, then clean the mating surfaces with lacquer thinner or acetone. If there's sealant or oil on the mating surfaces when the cover is refitted, oil leaks may develop.

12 Clean the mounting bolt threads with a die to remove any corrosion and restore damaged threads. Make sure the threaded holes in the cylinder head are clean - run a tap into them to remove corrosion and restore damaged threads.

13 The manufacturer recommends installing tool EN-46101 to the spark plug tube holes to allow the spark plug tube seals to slide over the tubes without tearing. However, after applying a small amount of engine oil to the spark plug tube seal inner faces and with care, the valve cover with the seals attached can slide over the spark plug tubes without the special tools.

14 The gaskets should be mated to the covers before the covers are refitted. Position the gasket inside the cover lip (see illustration). If the gasket will not stay in place in the cover lip, apply a thin coat of RTV sealant to the cover flange, and allow the sealant to cure slightly, so the gasket adheres to the cover.



4.15 Place some RTV sealant between the timing cover and cylinder head mating face

15 Apply a 3 mm bead of RTV sealant to the joints between the timing cover and cylinder head mating faces where the valve cover will sit (see illustration).

16 Inspect the valve cover bolt grommets for damage. If the grommets aren't damaged they can be reused. Carefully position the valve cover(s) on the cylinder head and refit the bolts and grommets.

17 Tighten the bolts in three or four steps to the torque listed in this Chapter's Specifications.

18 The remaining refitting steps are the reverse of removal.

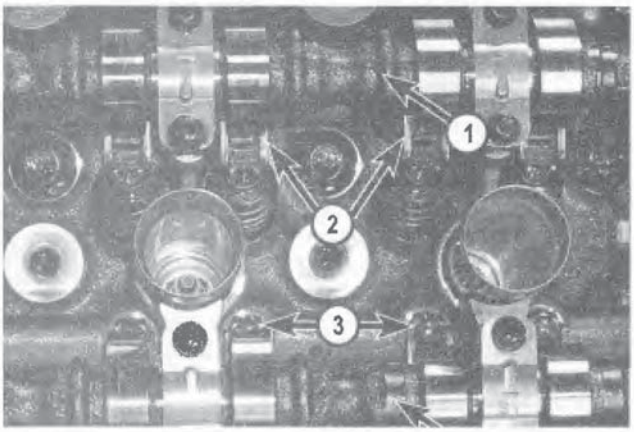
19 Start the engine and check carefully for oil leaks as the engine warms up.

5 Rocker arms and hydraulic lifters - removal, inspection and refitting

REMOVAL

Refer to illustration 5.2

1 Refer to Section 4 and detach the valve covers from the cylinder heads.



5.2 Remove the camshafts (1) to remove the rockers (2). The lifter socket on the rocker is labelled 3

2 Refer to Section 13 and remove the camshafts (see illustration).

3 Place markings on each rocker arm to ensure they are returned to the same position, then lift each one from the engine. Once the rocker arms are removed, the hydraulic lifters can be lifted from the cylinder head.

> ***Note:*** *It is important that any rocker arms or lifters being used again must be returned to their original position on the engine.*

INSPECTION

Refer to illustration 5.4

4 Check each rocker arm for wear, cracks and other damage, especially where the valve stems contact the rocker arm (see illustration).

5 Check the rollers for binding and roughness. If the bearings are worn or damaged, renewal of the entire rocker arm will be necessary.

> ***Note:*** *Keep in mind that there is no valve adjustment on these engines, so excessive wear or damage in the valve train can easily result in excessive valve clearance, which in turn will cause valve noise when the engine is running.*

Also check the rocker arm pivot support pedestal for cracks and other obvious damage.

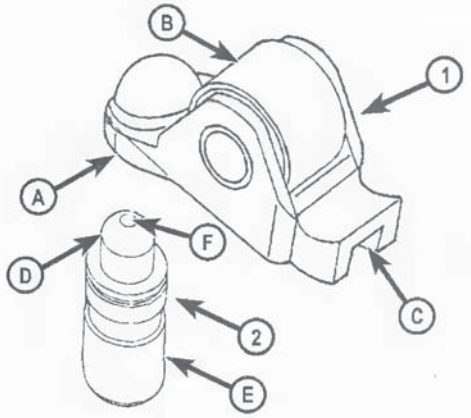
6 Make sure the oil passage hole in each hydraulic lifter is not blocked, and there are no burrs on the base of the lifter (see illustration 5.4).

REFITTING

7 Apply some camshaft/lifter pre-lube to the pivot pockets, roller and the slot that contacts the valve on each rocker arm. Apply clean engine oil into the bores for the hydraulic lifters and then install them into the cylinder head. Position the rocker arms onto the lifters.

8 The remaining refitting steps are the reverse of removal.

9 Before starting and running the engine, change the oil and fit a new oil filter (see Chapter 1).



5.4 Rocker arm (1) and hydraulic lifter (2) wear points

A	*Lifter socket*	*D*	*Lifter to rocker contact point*
B	*Roller*	*E*	*Lifter base*
C	*Valve stem contact point*	*F*	*Lifter oil passage*

6 Valve springs, retainers and seals - renewal

Refer to illustrations 6.4, 6.5, 6.7a, 6.7b and 6.16

> ***Note:*** *Broken valve springs and defective valve stem seals can be renewed without removing the cylinder head. Two special tools and a compressed air source are normally required to perform this operation, so read through this Section carefully and rent or buy the tools before beginning the job.*

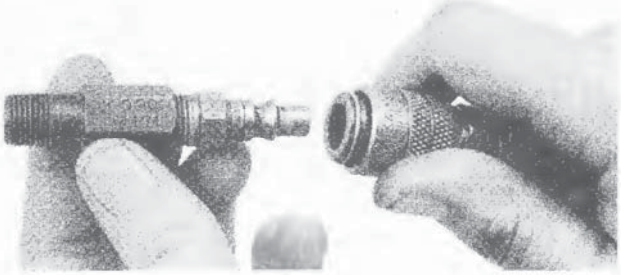
1 Remove the spark plugs (see Chapter 1).

2 Remove the plenum and inlet manifold (see Section 7), valve covers (see Section 4), timing chains (see Section 12), camshafts (see Section 13) and rocker arms (see Section 5).

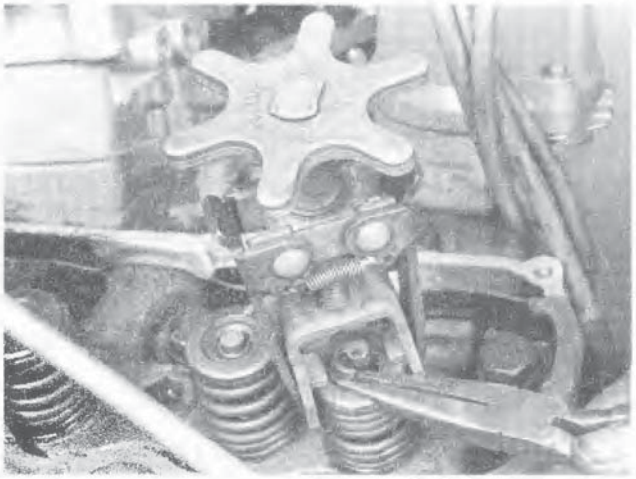
3 Thread an adapter into the spark plug hole and connect an air hose from a compressed air source to it. Most auto parts stores can supply the air hose adapter.

> ***Note:*** *Many cylinder compression gauges utilize a screw-in fitting that may work with your air hose quick-disconnect fitting. If a cylinder compression gauge fitting is used, it will be necessary to remove the Schrader valve from the end of the fitting before using it in this procedure.*

4 Apply compressed air to the cylinder. The valves should be held in place by the air pressure (see illustration).



6.4 This what the air hose adapter that threads into the spark plug hole looks like - they are commonly available at auto parts stores



6.5 After compressing the valve spring, remove the collets with a magnet or needle-nose pliers

5 Using a socket and a hammer, gently tap on the top of each valve spring retainer several times (this will break the seal between the valve collet and the spring retainer and allow the collet to separate from the valve spring retainer as the valve spring is compressed), then use a valve-spring compressor to compress the spring. Remove the collets with small needle-nose pliers or a magnet (see illustration).

> ***Note:*** *Several different types of tools are available for compressing the valve springs with the head in place. One type grips the lower spring coils and presses on the retainer as the knob is turned, while the lever-type shown here utilizes the rocker arm bolt for leverage. Both types work very well, although the lever type is usually less expensive.*

6 Remove the valve spring and retainer.

> ***Note:*** *If air pressure fails to retain the valve in the closed position during this operation, the valve face or seat may be damaged. If so, the cylinder head will have to be removed for repair.*

7 Remove the old valve stem seals, noting differences between the inlet and exhaust seals (see illustrations).

8 Wrap a rubber band or tape around the top of the valve stem so the valve won't fall into the combustion chamber, then release the air pressure.

9 Inspect the valve stem for damage. Rotate the valve in the guide and check the end for eccentric movement, which would indicate that the valve is bent.

10 Move the valve up-and-down in the guide and make sure it does not bind. If the valve stem binds, either the valve is bent or the guide is damaged. In either case, the head will have to be removed for repair.

11 Reapply air pressure to the cylinder to retain the valve in the closed position, then remove the tape or rubber band from the valve stem.

12 If you're working on an exhaust valve, fit the new exhaust valve seal on the valve stem and press it down over the valve guide to the specified depth. Don't force the seal against the top of the guide.

> ***Note:*** *Take this measurement from the steel spring seat to the top edge of the inlet and exhaust valve seals, not from the aluminium seat on the head!*

13 If you're working on an inlet valve, refit a new inlet valve stem seal over the valve stem and press it down over the valve guide to the specified depth. Don't force the inlet valve seal against the top of the guide.

> ***Caution:*** *Do not fit an exhaust valve seal on an inlet valve, as high oil consumption will result.*

14 Refit the spring and retainer in position over the valve.

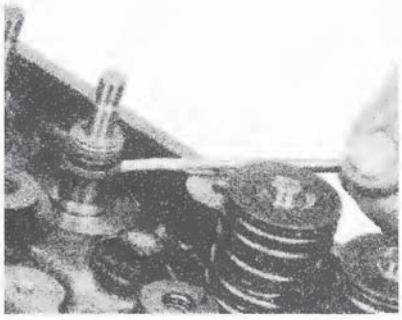
15 Compress the valve spring assembly only enough to refit the collets in the valve stem.

16 Position the collets in the valve stem groove. Apply a small dab of grease to the inside of each collet to hold it in place if necessary (see illustration). Remove the pressure from the spring tool and make sure the collets are seated.

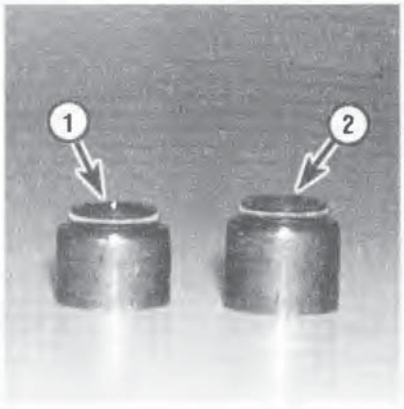
17 Disconnect the air hose and remove the adapter from the spark plug hole.

18 Repeat the above procedure on the remaining cylinders.

19 Refit the rocker arm assemblies, camshafts, timing chains and the valve covers (see appropriate Sections).



6.7a A screwdriver can be used to prise off the valve seals

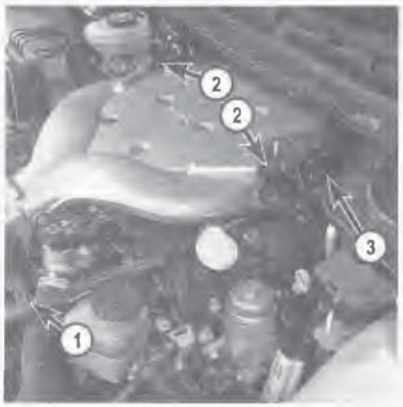


6.7b Ensure the seals are fitted to the correct valve stems

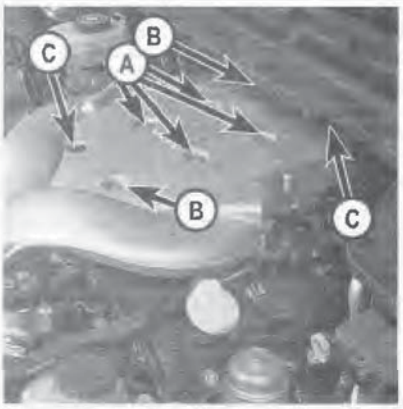
1 Inlet valve seal
2 Exhaust valve seal

6.16 Apply a small dab of grease to each collet as shown here before refitting - it'll hold them in place on the valve stem as the spring is released

7.4 Release the engine cover clips at the points illustrated



7.6 Throttle control motor connector (1), PCV hoses (2), canister purge solenoid location (3)



7.8 To remove the plenum from the inlet manifold, remove bolts A and B. To remove the plenum chamber and inlet manifold as an assembly, remove bolts A and C

20 Start the engine, then check for oil leaks and unusual sounds coming from the valve cover area. Allow the engine to idle for at least five minutes before revving the engine.

7 Plenum and inlet manifold - removal and refitting

Warning: *Wait until the engine is completely cool before starting this procedure.*

REMOVAL

Refer to illustration 7.4, 7.6, 7.8 and 7.11

1 Relieve the fuel system pressure (see Chapter 4).

2 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

3 Remove the suspension brace from on top of the front struts (see Chapter 10).

4 Remove the engine dress covers (see illustration).

5 Disconnect the wiring from the air flow sensor and remove the air inlet duct from between the throttle body and the air cleaner.

6 Disconnect the wiring from the throttle control motor then disconnect the throttle control motor wiring harness from the inlet manifold. Disconnect the PCV pipe from the hoses on each side of the plenum and disconnect the air pipe from the rear of the LH rocker cover (see illustration).

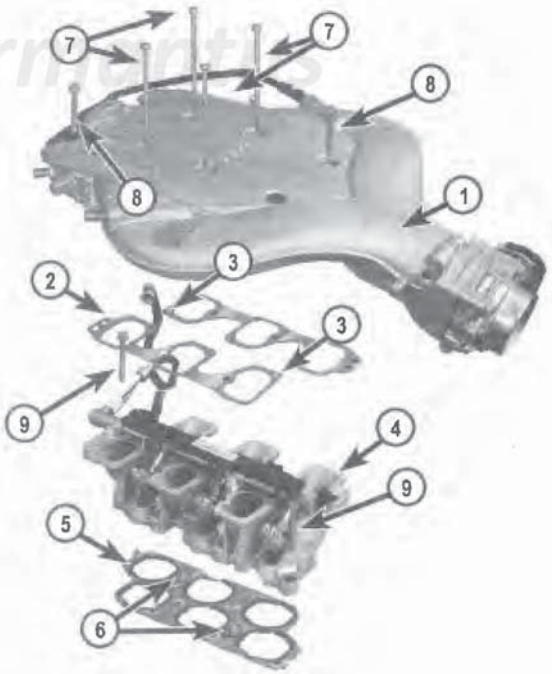
7 Working at the rear of the engine, disconnect the wiring from the barometric pressure sensor, the fuel injector block connector and the variable intake manifold control valve motor. Disconnect the PCV pipe from the retaining bracket near the barometric pressure sensor.

8 Remove the illustrated bolts (see illustration).

9 Lift the plenum from the inlet manifold. As the plenum is lifted from the engine, be sure to check for, and disconnect, anything still attached to the manifold.

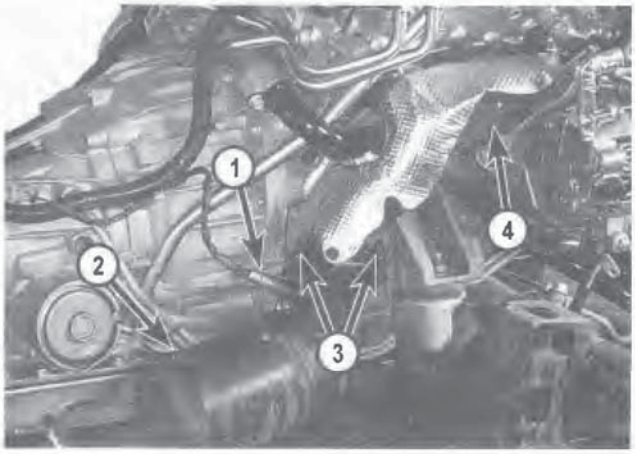
10 Disconnect the fuel line from the rear of the fuel rail (see Chapter 4).

11 Remove the remaining bolts holding the inlet manifold to the cylinder heads (see illustration). Lift the inlet manifold from the engine with the fuel rail and injectors attached.



7.11 Inlet manifold components

1 *Plenum*
2 *Gasket*
3 *Gasket re-fitting tabs*
4 *Inlet manifold*
5 *Gasket*
5 *Inlet manifold to cylinder head bolts*
6 *Gasket re-fitting tabs*
7 *Plenum to cylinder head bolts*
8 *Plenum to inlet manifold bolts*
9 *Inlet manifold to cylinder head bolts*



8.4 Exhaust manifold components

1 *Oxygen sensor*
2 *Catalytic converter*
3 *Nuts*
4 *Exhaust manifold*

12 Remove the bolts holding the fuel rail to the inlet manifold. Lift the fuel rail and injectors as an assembly from the manifold.

REFITTING

Note: *The mating surfaces of the cylinder heads, and manifold must be perfectly clean when the manifold is refitted.*

13 Carefully remove all traces of old gasket material. Note that the inlet manifold is made of a composite material and the cylinder heads are made of aluminium, therefore aggressive scraping is not suggested and will damage the sealing surfaces. After the gasket surfaces are cleaned and free of any gasket material, wipe the mating surfaces with a cloth saturated with solvent. If there is old sealant or oil on the mating surfaces when the manifold is refitted, oil or vacuum leaks may develop. Use a vacuum cleaner to remove any gasket material that falls into the inlet ports in the heads.

14 Use a tap of the correct size to chase the threads in the bolt holes, then use compressed air (if available) to remove the debris from the holes.

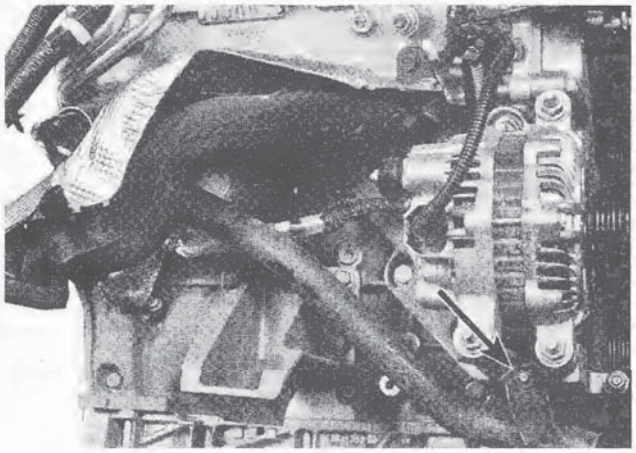
Warning: *Wear safety glasses or a face shield to protect your eyes when using compressed air.*

15 Position the new gaskets on the inlet manifold. Note that the gaskets are equipped with refitting tabs that must snap into place on the inlet manifold (see illustration 7.11). The words "Manifold Side" may appear on the gasket, If so, this will ensure proper refitting. Make sure the gaskets snap into place and all inlet port openings align.

16 Carefully set the manifold in place.

17 Apply medium-strength thread locking compound to the threads of the bolts. Refit the bolts and tighten them starting with the four long bolts and working toward each end of the manifold to the torque listed in this Chapter's Specifications. Do not overtighten the bolts or gasket leaks may develop.

18 The remaining refitting steps are the reverse of removal. Check the coolant level, adding as necessary (see Chapter 1). Start the engine and check carefully for vacuum leaks at the inlet manifold joints.



8.8 Remove the nut holding the bottom of the coolant pipe and push the pipe down to gain access to the lower manifold bolts

8 Exhaust manifolds - removal and refitting

REMOVAL

Refer to illustration 8.4

Warning: *Use caution when working around the exhaust manifolds - the sheetmetal heat shields can be sharp on the edges. Also, the engine should be cold when this procedure is followed.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Raise the vehicle and support it securely on jackstands.

3 Working under the vehicle, apply penetrating oil to the catalytic converter-to-manifold studs and nuts (they're usually rusty).

4 Remove the nuts retaining the catalytic converter to the manifold (see illustration).

5 Disconnect the electrical connectors for the oxygen sensors and unclip the wiring harness from the engine. Move the harness clear of the work area.

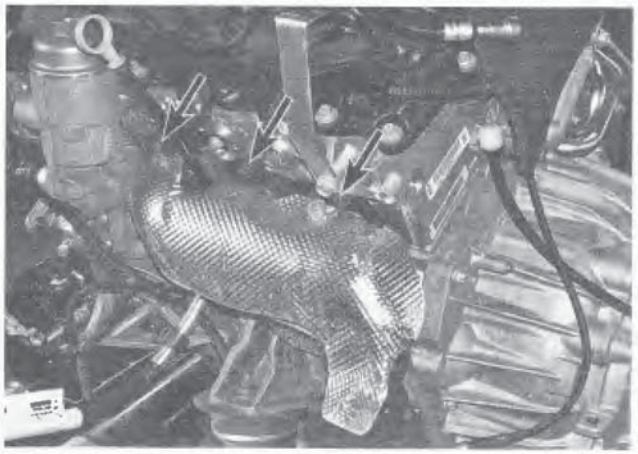
Right side manifold

Refer to illustration 8.8

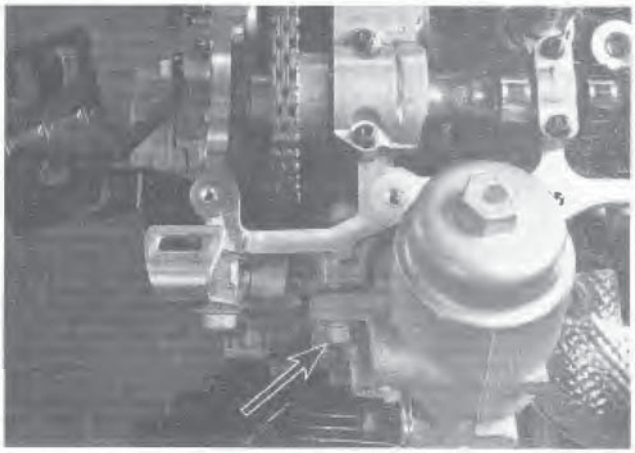
6 Remove the engine covers. Also remove the alternator (see Chapter 5).

7 Remove the retaining bolts and then remove the outer heat shield. Remove the earth wire from the coolant pipe mounting bracket beneath the manifold.

8 Push the coolant pipe down to access the lower manifold bolts. Remove the mounting bolts, starting with the outside bolts and working toward the centre of the manifold. Separate the exhaust manifold from the cylinder head (see illustration). Remove the inner heat shields from the manifold after the manifold has been removed.



8.9 Exhaust manifold fastener locations (left side shown, right side similar)



9.4 Remove the oil filter housing bolt from the LH cylinder head. There is no need to remove any other oil filter housing bolts

Left side manifold

Refer to illustration 8.9

9 Remove the mounting bolts, starting with the outside bolts and working toward the centre of the manifold. Separate the exhaust manifold from the cylinder head (see illustration). Remove the inner heat shields from the manifold after the manifold has been removed.

REFITTING

10 Check the manifold for cracks and make sure the bolt threads are clean and undamaged. The manifold and cylinder head mating surfaces must be clean before the manifolds are refitted - use a gasket scraper to remove all carbon deposits and gasket material.

> ***Note:*** *The cylinder heads are made of aluminium, therefore aggressive scraping is not suggested and will damage the sealing surfaces. Also, if any of the manifold bolts are broken it indicates a warped manifold. Have the manifold machined at a cylinder head reconditioning workshop prior to installing the manifold to the vehicle. If this is not done, the manifold may not seal properly and the new manifold bolts will probably break.*

11 Apply an anti-seize compound to the threads of the inner heat shield bolts. Refit the inner heat shields, then refit the bolts and gaskets onto the manifold. Retaining tabs surrounding the gasket bolt holes should hold the assembly together as the manifold is refitted.

12 Apply a 5 mm wide band of medium-strength thread locking compound to the threads of the bolts.

13 Place the manifold on the cylinder head and refit the mounting bolts finger tight.

14 When tightening the manifold bolts, work from the centre to the ends and be sure to use a torque wrench. Tighten the bolts to the torque listed in this Chapter's Specifications. If required, bend the exposed end of the exhaust manifold gasket back against the cylinder head.

15 Apply an anti-seize compound to the threads of the outer heat shield and install the heat shield bolts.

16 The remaining refitting steps are the reverse of removal.

17 Start the engine and check for exhaust leaks.

9 Cylinder heads - removal and refitting

> ***Note:*** *It will be necessary to purchase a new set of 11 mm head bolts before or during this procedure.*

REMOVAL

Refer to illustration 9.4

1 Disconnect the cable from the negative terminal of the battery and drain the cooling system (see Chapter 1).

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the plenum and inlet manifold (see Section 7), valve covers (see Section 4) and timing chains and camshaft sprockets (see Section 12).

3 Detach both exhaust manifolds from the cylinder heads (see Section 8).

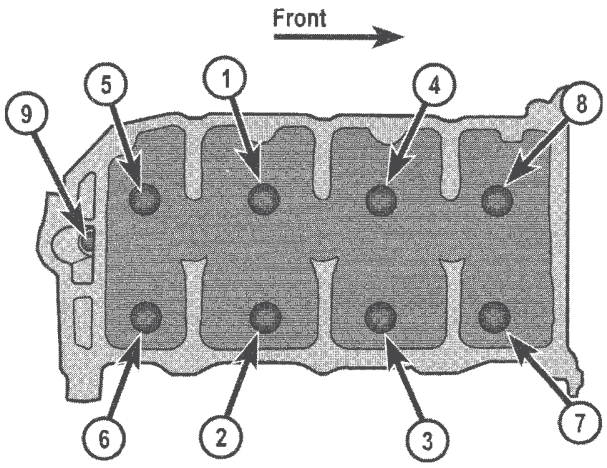
4 Remove the upper bolt from the oil filter adapter (see illustration).

5 Loosen the head bolts in 1/4-turn increments in the reverse order of the tightening sequence (see illustration 9.15a or 9.15b) until they can be removed by hand.

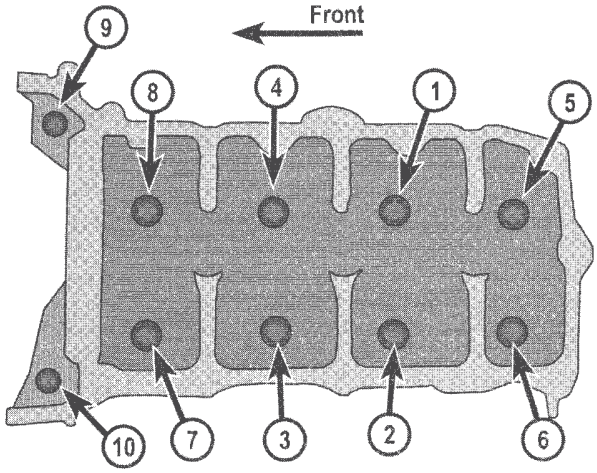
> ***Note:*** *There will be different length and size head bolts for different locations. Make a note of the different sizes and lengths and where they go when removing the bolts to ensure correct refitting of the new bolts.*

6 Lift the heads off the engine. If resistance is felt, do not prise between the head and block as damage to the mating surfaces will result. To dislodge the head, place a prise bar or long screwdriver into the inlet port and carefully prise the head off the engine. Store the heads on blocks of wood to prevent damage to the gasket sealing surfaces.

7 Cylinder head disassembly and inspection procedures are covered in detail in Chapter 2, Part E.



9.15a RH cylinder head tightening sequence. Bolts 1 to 8 are M11 bolts. Bolt 9 is a M8 bolt



9.15b LH cylinder head bolt tightening sequence. Bolts 1 to 8 are M11 bolts. Bolts 9 and 10 are M8 bolts

REFITTING

Refer to illustrations 9.15a and 9.15b

8 The mating surfaces of the cylinder heads and block must be perfectly clean when the heads are refitted. Gasket removal solvents are available at auto parts stores and may prove helpful.

9 Use a gasket scraper to remove all traces of carbon and old gasket material, then wipe the mating surfaces with a cloth saturated with lacquer thinner or acetone.

> ***Note:*** *The cylinder heads are made of aluminium, therefore aggressive scraping is not suggested and will damage the sealing surfaces.*

If there is oil on the mating surfaces when the heads are refitted, the gaskets may not seal correctly and leaks may develop. When working on the block, use a vacuum cleaner to remove any debris that falls into the cylinders.

10 Check the block and head mating surfaces for nicks, deep scratches and other damage. If damage is slight, it can be removed with emery cloth. If it is excessive, machining may be the only alternative.

11 Use a tap of the correct size to chase the threads in the head bolt holes in the block. If a tap is not available, spray a liberal amount of brake cleaner into each hole. Use compressed air (if available) to remove the debris from the holes.

> ***Warning:*** *Wear safety glasses or a face shield to protect your eyes when using compressed air.*

Use a wire brush to remove the thread locking compound from the 8 mm head bolts. Corrosion, sealant and damaged threads will affect torque readings, so be sure the threads are clean.

12 Position the new gaskets over the dowels in the block.

13 Carefully position the heads on the block without disturbing the gaskets.

14 Before refitting the 8mm head bolts, coat the threads with a medium-strength thread locking compound. Then refit the 8mm head bolts 9 (and 10 on LH cylinder head) finger tight.

15 Refit New 11 mm head bolts (bolts 1 through 8) and tighten them finger tight. Following the recommended sequence (see illustrations), tighten the bolts in four steps to the torque and angle of rotation listed in this Chapter's Specifications.

> ***Warning:*** *DO NOT reuse 11mm head bolts - always renew them.*

16 The remaining refitting steps are the reverse of removal.

17 Add coolant and change the oil and filter (see Chapter 1). Start the engine and check for proper operation and coolant or oil leaks.

10 Crankshaft balancer - removal and refitting

Refer to illustrations 10.4, 10.5, 10.8a and 10.8b

> ***Note:*** *This procedure requires a special balancer refitting tool that is available through specialized tool manufacturers only and a new crankshaft balancer bolt. Read through the entire procedure and obtain the tool and materials before proceeding.*

1 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Raise the front of the vehicle and support it securely on jackstands.

3 Remove the drivebelt (see Chapter 1).

4 Remove the starter motor (see Chapter 5). Use a lever through the rear of the engine block to hold the ring gear teeth on the driveplate/flywheel and loosen the crankshaft pulley centre bolt (see illustration).

5 Pull the balancer off the crankshaft with a puller (see illustration).

> ***Caution:*** *The jaws of the puller must only contact the hub of the balancer - not the outer ring.*

10.4 Place a lever between the ring gear teeth and the cylinder block to hold the crankshaft while removing the centre bolt

10.5 The use of a three jaw puller will be necessary to remove the crankshaft balancer - always place the puller jaws around the hub, not the outer ring

Note: *A long Allen-head bolt should be inserted into the crankshaft nose for the puller's tapered tip to push against to prevent damage to the crankshaft threads.*

6 Lubricate the end of the crankshaft and oils seal with clean engine oil. Position the crankshaft pulley/balancer on the crankshaft and slide it on as far as it will go. Note that the slot (keyway) in the hub must be aligned with the Woodruff key in the end of the crankshaft.

7 Hold the crankshaft steady and use the old crankshaft balancer bolt to press the balancer onto the crankshaft and tighten it to 100 Nm.

8 Refit a New crankshaft balancer bolt and tighten it in two steps to the torque and angle of rotation listed in this Chapter's Specifications (see illustrations).

9 The remaining refitting steps are the reverse of removal.

11 Crankshaft front oil seal - removal and refitting

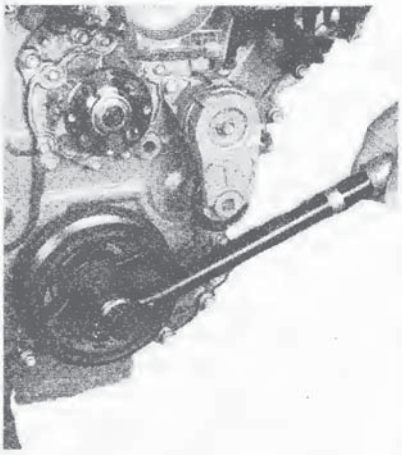
Refer to illustrations 11.2 and 11.5

1 Remove the crankshaft balancer (see Section 10).

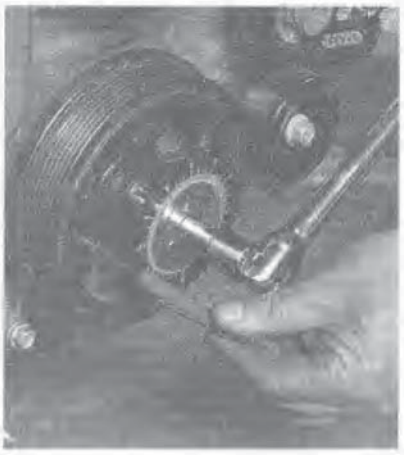
2 Note how the seal is refitted - the new one must be refitted to the same depth and facing the same way. Carefully prise the oil seal out of the cover with a seal puller (see illustration).

3 If the seal is being renewed with the timing chain cover removed, support the cover on top of two blocks of wood and drive the seal out from the backside with a hammer and punch.

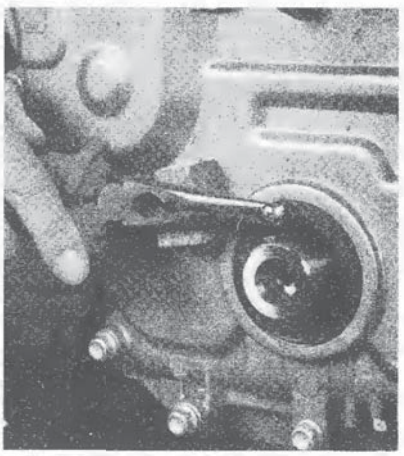
Caution: *Be careful not to scratch, gouge or distort the area that the seal fits into or a leak will develop.*



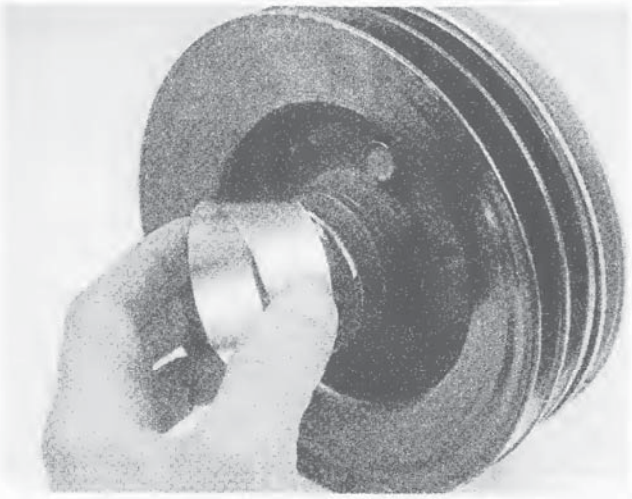
10.8a Tightening the new crankshaft balancer bolt to the specified torque



10.8b Using a torque angle gauge to finish the tightening sequence



11.2 Another way of removing an old oil seal is to screw a self tapping screw partially into the seal, then use pliers as a lever to pull it from the engine



11.5 If the sealing surface of the pulley hub has a wear groove from contact with the seal, repair sleeves are available at most auto parts stores

4 Apply clean engine oil or multi-purpose grease to the outer edge of the new seal, then refit it in the cover with the lip (spring side) facing IN. Drive the seal into place with a large socket and a hammer (if a large socket isn't available, a piece of pipe will also work). Make sure the seal enters the bore squarely and stop when the front face is at the proper depth.

5 Check the surface on the balancer hub that the oil seal rides on. If the surface has been grooved from long-time contact with the seal, a press-on sleeve may be available to renew the sealing surface (see illustration). This sleeve is pressed into place with a hammer and a block of wood and is commonly available at auto parts stores for various applications.

6 Lubricate the balancer hub with clean engine oil and refit the crankshaft balancer as described in Section 10.

7 The remainder of refitting is the reverse of the removal.

12 Timing chain and camshaft sprockets - removal, inspection and refitting

REMOVAL

Refer to illustrations 12.9a, 12.9b, 12.10, 12.11a, 12.11b and 12.13

Note: *This procedure requires two special tools to lock the camshafts on each cylinder head in position. The part numbers for the tools are EN-46105-1 and EN-46105-2 and they are available through SPX tools. Read through the entire procedure and obtain the tools before proceeding.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Refer to Chapter 1 and drain the cooling system.

3 Remove the valve covers (see Section 4).

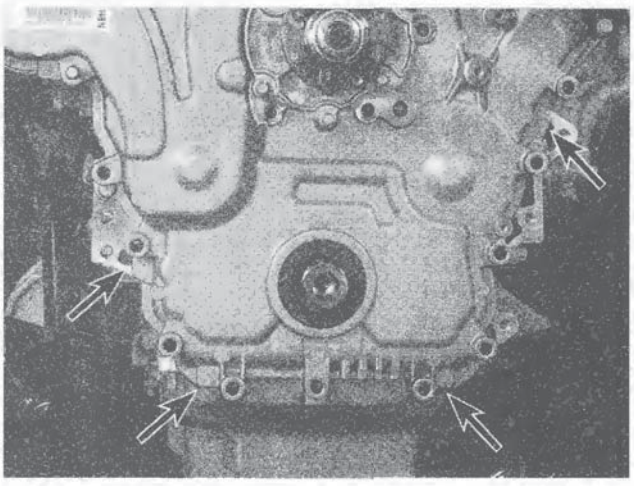
4 Refer to Chapter 4 and remove the air cleaner and the air inlet duct from the engine compartment, then refer to Chapter 3 and remove the upper and lower radiator hoses, coolant recovery hose, the cooling fans, drivebelt and coolant outlet pipe (incorporating the radiator cap).

5 Remove the crankshaft balancer (see Section 10).

6 Remove the bolts retaining the power steering pump reservoir and associated brackets. Do not open any of the power steering lines. Position the reservoir and bracket as an assembly clear of the work area.

7 Remove the bolts retaining the A/C compressor and associated brackets. Do not open any A/C refrigerant lines. Position the compressor and brackets as an assembly clear of the work area.

8 Disconnect the wiring connectors and remove each camshaft position sensor. Also disconnect the wiring and remove the variable cam timing solenoids from the front of the engine.



12.9a Use a screwdriver to lever the cover from the engine at the illustrated points

12.9b A 10 x 1.5 mm bolt can be used at the illustrated point, near the water pump to press the centre portion of the cover away from the engine.

12.10 Crankshaft sprocket in correct position

12.11a RH cylinder head with camshaft locking tool fitted

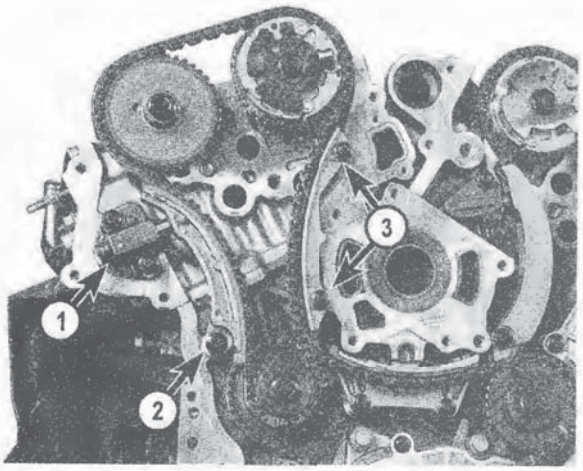
12.11b LH cylinder head with camshaft locking tool fitted

9 Remove the timing chain cover mounting bolts (see illustration 12.36) and separate the timing chain cover from the block (see illustrations). The cover may be stuck; if so, lever only at the points illustrated with a screwdriver. Since the cover is made of aluminium it can easily be damaged, so DO NOT attempt to prise it off.

10 Rotate the crankshaft clockwise until the timing mark on the timing chain sprocket aligns with the mark on the oil pump housing in the 9 o'clock position (see illustration).

11 In this position, the flat segment on the rear of each camshaft on the RH cylinder head should be facing up and parallel with the valve cover mating face. If this is not the case, rotate the crankshaft clockwise one full turn and re-align the crankshaft timing marks. Fit the special tools to the camshafts of each cylinder head (see illustrations).

Note: The tool EC-46105-1 is the tool that will be fitted to the RH cylinder head for dismantling. This is where the flats on the rear of the camshafts are parallel to the gasket mating face for the valve cover. The second locking tool ECV-46105-2 will be fitted to the LH cylinder head.



12.13 RH cylinder head timing chain tensioner (1), outer guide pivot bolt (2) and inner guide bolts (3)

12 Remove the timing chain tensioner bolts for the RH cylinder head and carefully remove the tensioner and discard the gasket.

Note: The tensioner is under spring pressure. Use care as the tensioner can fly apart once the bolts are removed.

13 Remove the RH cylinder head timing chain guides and then remove the chain (see illustration). Remove the special holding tools from the rear of the camshafts.

14 Repeat the process to remove the lower, or primary timing chain and the timing chain for the LH cylinder head.

Note: The camshaft locking tools can remain off while removing the lower and LH cylinder head timing chains. Again use care as the tensioners are under spring pressure. Also, do not attempt to remove the timing chain guide from the oil pump housing. At the time of publication, this was only supplied as a complete assembly with the oil pump.

15 If necessary, after noting their installed position, remove the bolts retaining the idler sprockets and remove the sprockets.

16 If necessary, mark the relationship between the camshaft sprockets and their respective camshaft. Hold the camshaft steady with an open ended spanner placed on the hexagonal in the camshaft and remove the camshaft sprocket bolt. Remove the sprocket from the camshaft.

INSPECTION

Refer to illustrations 12.20a and 12.20b

17 Inspect the timing chain cover for damage. Remove all old sealant from the cover and the engine block. Remove and discard the seal for the coolant passage from the rear of the housing.

18 Clean all components with suitable solvent and inspect the guides and timing chain sprockets for wear or damage. Any gouges or deformities on the guides or tensioners will require replacement parts fitted. Ensure the rear face of the tensioner is clean and there are no marks that would affect the sealing quality once reassembled. Remove any old gasket material from the tensioner mating faces with the engine.

19 Inspect the timing chains for wear, stiff or loose rollers and binding.

20 Inspect the tensioners for damage or wear. Reset the tensioner by removing the plunger from the tensioner body and screw the rear of the plunger into the plunger shaft using a flat bladed screwdriver. Install the plunger to the body of the tensioner and while maintaining pressure on the plunger insert a paper clip into the hole in the tensioner body to maintain the tensioner in the retracted position (see illustrations). Repeat this on the other two timing chain tensioners.

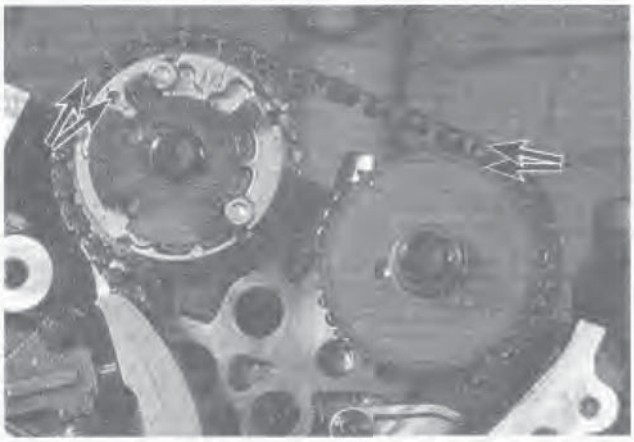
Note: *The wire must be inserted into the tensioner to maintain it in the compressed position. If this is not done, the spring pressure will not tension the chain once it is installed to the engine.*

12.20a Remove the plunger from the tensioner and reset it by screwing the bottom of the plunger shaft into the top half of the plunger shaft with a screwdriver

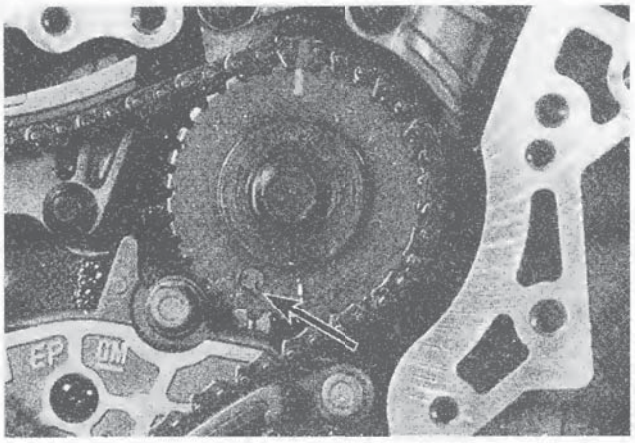
12.20b Slowly push the plunger back into the tensioner body and secure it in place with a paper clip

12.23a LH cylinder head with camshaft locking tool fitted

12.23b RH cylinder head with camshaft locking tool fitted



12.24a LH cylinder head timing chain-to-camshaft sprocket aligning marks



12.24b Alignment mark between LH timing chain and idler sprocket

REFITTING

Refer to illustrations 12.23a, 12.23b, 12.24a, 12.24b, 12.28, 12.30, 12.32, 12.34, 12.35 and 12.36

***Note:** Timing chains must be renewed as a set with the camshaft and crankshaft sprockets. Never put a new chain on old sprockets.*

21 Align the crankshaft sprocket with the Woodruff key and slide the sprocket onto the crankshaft. Ensure the timing mark on the sprocket is visible and the timing marks are aligned. If necessary, rotate the crankshaft clockwise and align the crankshaft sprocket mark with the mark on the oil pump housing that is in the 5 o'clock position.

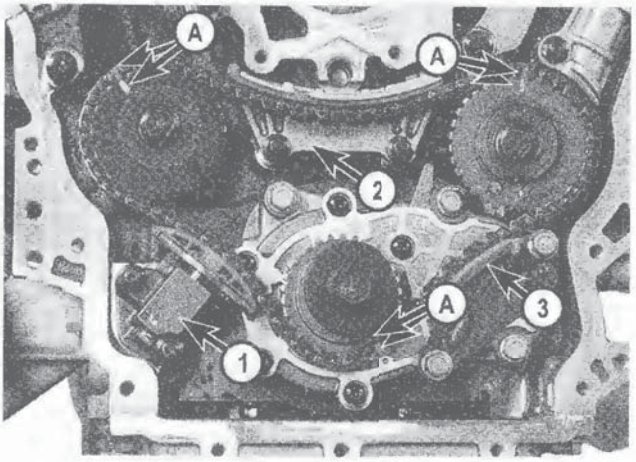
***Caution:** If resistance is encountered, do not hammer the sprocket onto the crankshaft. It may eventually move onto the shaft, but it may be cracked in the process and fail later, causing extensive engine damage.*

22 Rotate the camshafts for the LH cylinder head anti-clockwise using an open ended spanner on the hexagonal portion of the camshafts until the flats on the rear of the camshaft are parallel to the valve cover gasket face on the rear of the cylinder head.

23 Install the special locking tool EN-46105-1 onto the LH cylinder head camshafts. Ensure the tool is correctly seated against the camshafts. Rotate the camshafts for the RH cylinder head in the same way and install the other special locking tool to the RH cylinder head (EN-46105-2) (see illustrations).

24 Install the LH cylinder head timing chain first, aligning the bright chain links with the letter L stamped on the camshaft sprockets. Then install the LH lower idler sprocket onto the chain ensuring the large sprocket and the markings "LB Front" are facing outward. The lower bright link on the chain must align with the hole in the face of the outer sprocket (see illustrations). Slide the idler sprocket onto the engine and install the bolt. Tighten the idler sprocket bolt to the torque listed in this Chapter's Specifications and check that all of the timing marks are still aligned correctly.

25 Install the outer LH timing chain guide that runs between the idler sprocket and the exhaust camshaft, then install the inner LH timing chain guide to the engine. Tighten the bolts to the torque listed in this Chapter's Specifications.



12.28 Lower timing chain sprocket aligning marks (A). The tensioner (1), upper timing chain guide (2) and lower timing chain guide (3)

***Note:** Ensure the inner timing chain guide is not fouling on the mounting pad for the tensioner before tightening the bolts.*

26 Using a new gasket, install the tensioner for the LH timing chain. Ensure the tensioner is aligned with the inner guide and tighten the tensioner bolts to the torque listed in this Chapter's Specifications. Release the pin from the tensioner. Grasp the inner guide and force it into the tensioner. This will allow the tensioner to tension the chain and check that the timing chain alignment marks are all correct.

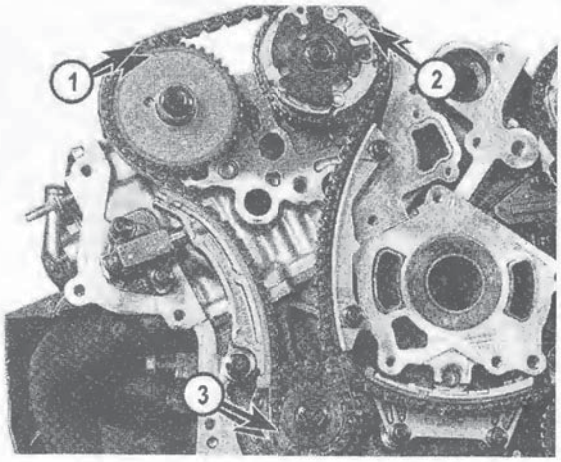
27 Install the RH timing chain idler sprocket to the engine ensuring that the small sprocket is facing outward along with the markings "RB Front". Tighten the idler sprocket bolt to the torque listed in this Chapter's Specifications.

28 Ensure the crankshaft sprocket is still aligned with the timing mark on the oil pump housing that is in the 5 o'clock position and install the lower, or primary timing chain. Ensure the shiny chain links align with the arrows on both large idler sprockets and also with the timing mark on the crankshaft sprocket. Install the timing chain guide to the lower chain running between the two idler sprockets, tightening the bolts to the torque listed in this Chapter's Specifications. Then using a new gasket, install the tensioner and tighten the tensioner bolts. Remove the pin from the tensioner, force the tensioner guide and pushrod into the tensioner body to unlock it. Allow the tensioner to tension the timing chain. Check that the timing chain alignment marks are all correct. Remove the camshaft special locking tools from the camshafts on both cylinder heads (see illustration).

29 Rotate the crankshaft until the timing mark on the crankshaft sprocket is aligned with the mark on the oil pump housing that is in the 9 o'clock position. Install the special locking tool EN-46105-2 onto the LH cylinder head camshafts. Rotate the camshafts for the RH cylinder head and install the other special locking tool to the RH cylinder head (EN-46105-1). Ensure the tools are correctly seated against the camshafts (see illustrations 12.11a and 12.11b).

***Note:** The camshaft flats for the RH cylinder head must be parallel to the valve cover gasket face on the rear of the cylinder head.*

30 Install the RH cylinder head timing chain, aligning the bright chain links with the letter R stamped on the camshaft



12.30 RH cylinder head timing chain alignment marks (1) exhaust camshaft, (2) inlet camshaft, (3) idler sprocket

12.32 Force the tensioner guide and chain into the tensioner body to unlock the tensioner

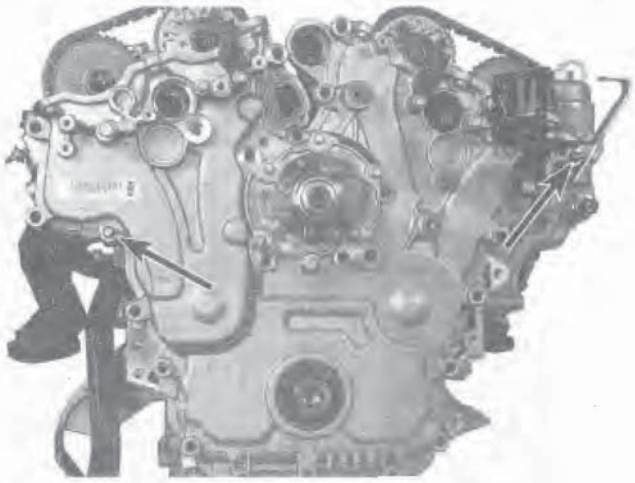
sprockets. The lower bright link on the chain must align with the hole in the face of the inner idler sprocket. Check that all of the timing marks are still aligned correctly (see illustration).

31 Install the inner RH timing chain guide that runs between the idler sprocket and the inlet camshaft, then install the outer RH timing chain guide to the engine. Tighten the bolts to the torque listed in this Chapter's Specifications.

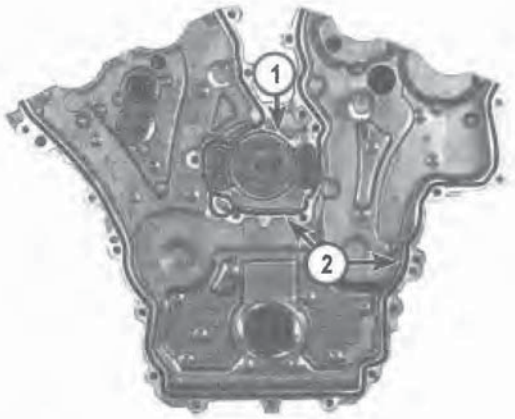
32 Using a new gasket, install the tensioner for the RH timing chain. Ensure the tensioner is aligned with the outer guide and tighten the tensioner bolts to the torque listed in this Chapter's Specifications. Remove the pin from the tensioner, force the tensioner guide and pushrod into the tensioner body to unlock it. Allow the tensioner to tension the timing chain (see illustration). Check that the timing chain alignment marks are all correct, then rotate the engine slowly by hand until oil is forced into the three timing chain tensioners.

> ***Note:*** *While doing this, ensure that the timing chains don't jump teeth on any of the timing gears.*

33 Remove the special locking tools from the camshafts.



12.35 Fabricate two timing cover aligning studs from M8 x 1.25 mm bolts with the heads removed and use the plastic sleeves that were between the original timing cover bolts and the timing cover to ensure the cover is in the correct position.



12.34 Seal location (1) and sealant location (2)

34 Install a new seal to the inside of the timing cover and apply a bead of RTV sealant to the faces of the cover that will mate with the engine (see illustration). Slide the timing chain cover over the crankshaft and the two studs, then install the bolts hand tight into the cover.

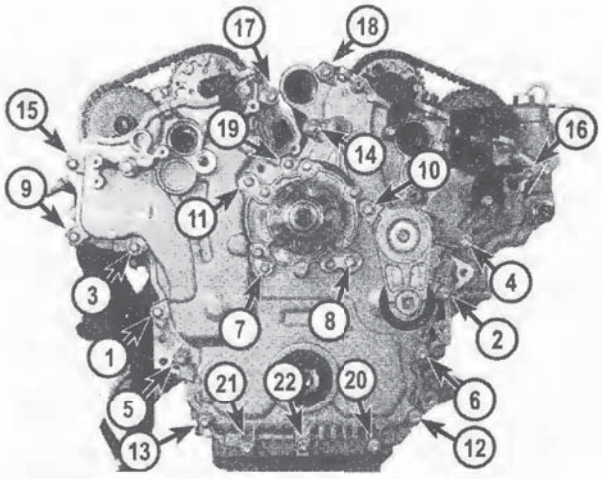
35 Fit two 8 mm studs into the engine block to guide the timing chain cover into the correct position (see illustration).

36 Remove the two 8 mm studs before tightening timing chain cover bolts in the illustrated order (see illustration).

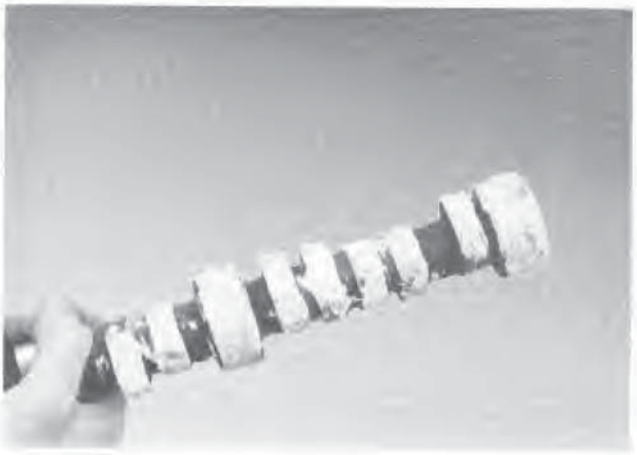
37 The remainder of refitting is the reverse of removal.

13 Camshafts - removal and refitting

> ***Note 1:*** *The camshaft should always be thoroughly inspected before refitting and camshaft endplay should always be checked prior to camshaft removal. Camshaft and lifter inspection procedures for this engine are identical to inspection procedures on the 3.8L V6 engine, therefore refer to Chapter 2A for the Camshaft and lifter inspection procedures.*



12.36 Timing cover bolt tightening sequence



13.6 Be sure to apply camshaft assembly lube to the cam lobes and bearing journals before refitting the camshaft

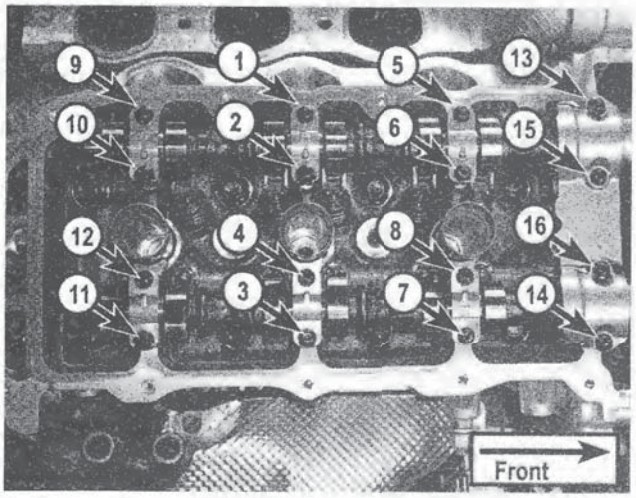
> ***Note 2:*** *If the camshaft is being renewed, always fit new rocker arms and hydraulic lifters as well. Do not use old rockers and lifters on a new camshaft.*

> ***Note 3:*** *The camshaft bearing caps are marked with a number and letter and a raised arrow. The number signifies the bearing journal (cylinder number) position from the front of the engine. The letter indicates whether it originates from the inlet camshaft (I), or the exhaust (E) camshaft and the arrow should always point toward the front of the engine.*

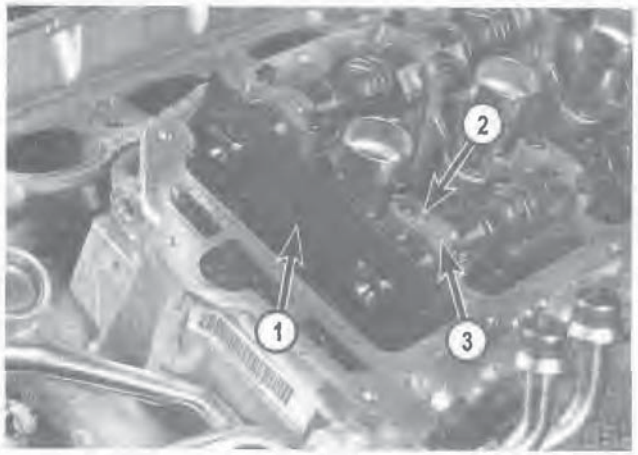
REMOVAL

1 Remove the plenum and inlet manifold (see Section 7), valve covers (see Section 4) and timing chains and camshaft sprockets (see Section 12).

2 Check the camshaft end play by mounting a dial gauge to the front of the engine with the plunger bearing against the end of the camshaft. Using a lever wrapped in rag, lever the camshaft toward the rear of the engine and zero the dial gauge. Then lever the camshaft toward the front of the engine and note the dial gauge. This is the camshaft end play. Compare with Specifications and repeat the test on the remaining camshafts. Any camshaft with excessive end play will have to be replaced.



13.9 RH cylinder head bearing cap tightening sequence



13.8 The camshafts are in the correct position if the special tool EN-46105-1 (1) can be installed to the rear of the camshafts. The camshaft bearing journals should have the tang (2) facing toward the centre of the cylinder head and the number (3) signifies the cylinder No for that mating journal and the letter next to the number indicates whether it is for the intake camshaft (I) or exhaust camshaft (E)

> ***Note:*** *Use care not to damage the lobes on the camshaft when levering it. The camshaft can easily be damaged.*

3 Before removing the bearing caps and lifters, arrange to store them in a clearly labelled box to ensure that they're refitted in their original locations.

4 Remove the camshaft bearing cap bolts and bearing caps and lift the camshafts from the cylinder head.

5 Inspect the camshafts for wear or damage (see Chapter 2A).

REFITTING

Refer to illustration 13.6, 13.8, 13.9 and 13.10

6 Ensure the sealing rings on the front of the camshafts are in place and lubricate the camshaft bearing journals and cam lobes with camshaft assembly lube (see illustration).

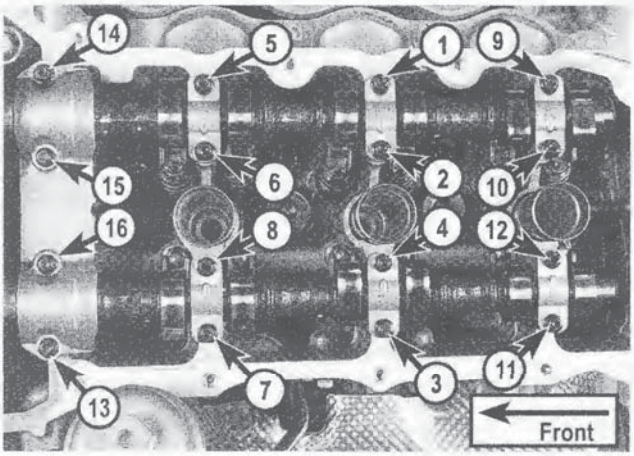
7 Working on the RH cylinder head, lubricate the bearing journals and place the camshafts onto the bearing journals. Position the camshafts so as the flat portions on the rear of the camshaft are parallel to the valve cover gasket face on the top of the cylinder head.

> ***Note:*** *It should be possible to install the camshaft lock tool Part No EN-46105-1 used when removing the timing chains and sprockets.*

8 Apply engine oil to the inside of the bearing caps and then install the front bearing cap first, ensuring the thrust face is correctly positioned. Then, install the remaining bearing caps and hand tighten the bolts (see illustration).

> ***Note:*** *Ensure the bearing caps are returned to their original position and the arrows face the centre of the cylinder head.*

9 Tighten the bearing cap bolts for both camshafts in the order illustrated (see illustration) to the torque listed in this Chapter's Specifications. Once the torque procedure is complete, loosen the bolts labelled 1,2 and 3,4 and re-torque them.



13.10 LH cylinder head bearing cap tightening sequence

10 Repeat steps 7 through 9 to install the LH cylinder head camshafts (see illustration).

11 The remaining refitting steps are the reverse of removal.

12 Before starting and running the engine, change the oil and fit a new oil filter (see Chapter 1).

14 Sump - removal and refitting

REMOVAL

Refer to illustration 14.4

1 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the engine assembly from the vehicle (see Chapter 2E).

3 Remove the plenum and inlet manifold (see Section 7), valve covers (see Section 4) and timing chain cover (see Section 12).

4 With the engine supported on a suitable engine stand, remove the two long bolts retaining the sump to the rear main oil seal housing. Then remove the remaining bolts holding the sump to the timing cover and engine block. Lever the sump from the engine block at the illustrated points (see illustration) and as the seal to the block is broken, the oil pickup pipe will disconnect from the oil pump.

5 If necessary, the oil level sensor can be removed by unscrewing it from the sump. The baffle inside the sump can be removed after removing the retaining bolts. The oil pickup can be removed once the bolts in the bottom of the sump are removed. Discard the oil pickup oil seal.

14.4 Arrow indicates a lever point to break the seal between the sump and cylinder block. There is another one at the front on the opposite side of the engine

REFITTING

Refer to illustration 14.11

6 Thoroughly clean the mounting surfaces of the sump and engine block of old gasket material and sealer. Wipe the gasket surfaces clean with a rag soaked in lacquer thinner, acetone or brake system cleaner.

7 Check the oil pump pickup for cracks or signs of leakage. Ensure the screen in the bottom of the pickup is not blocked or damaged.

8 Ensure a new oil seal is fitted to the oil pump pickup. Install the oil pickup and tighten the bolts in the bottom of the sump. Fit the baffle to the inside of the sump, tightening the retaining bolts.

9 Fabricate two aligning studs from M8 x 1.25 mm bolts with the heads removed and screw them into the sump bolt holes labelled 1 and 2 to allow for correct sump alignment (see illustration 14.11).

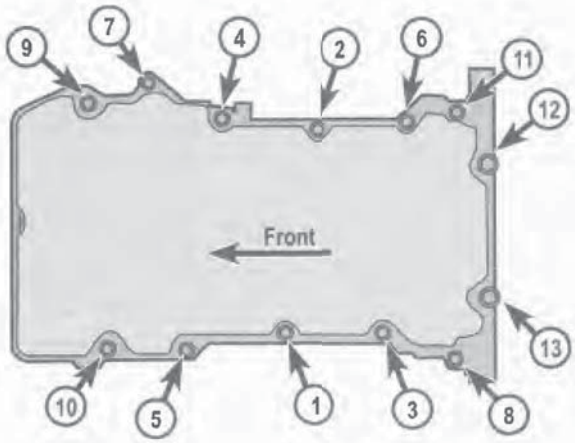
10 Apply a 3mm wide bead of oxygen sensor safe RTV sealant to the sump mating face with the engine block. Also apply some sealant to the corners of the block where the front cover and the rear cover meet the engine block. Attach the sump, refit the sump and tighten the bolts finger-tight.

11 Remove the threaded dowel pins before tightening the sump bolts in the order shown to the torque listed in this Chapter's Specifications (see illustration).

> ***Note:*** *Check Specifications for the correct torque. The two bolts holding the sump to the rear main oil seal housing are a different torque to the remaining bolts.*

12 The remainder of refitting is the reverse of removal.

13 Add the proper type and quantity of oil (see Chapter 1), start the engine and check for leaks before placing the vehicle back in service.



14.11 Sump bolt tightening sequence

15 Oil pump - removal, inspection and refitting

REMOVAL

Refer to illustration 15.2

1 Remove the plenum and inlet manifold (see Section 7), valve covers (see Section 4) and timing chains (see Section 12). After noting the installed position, remove the timing chain sprocket from the crankshaft.

2 Remove the oil pump retaining bolts and slide the pump off the end of the crankshaft (see illustration).

INSPECTION

3 Remove the timing chain guide from the oil pump housing then remove the oil pump cover and withdraw the rotors from the pump body. Remove the circlip from the side of the pump housing and withdraw the cap, spring and plunger from the oil pump housing. These components are the oil pressure relief valve assembly. Clean the components with solvent, dry them thoroughly and inspect for any obvious damage. Also check the bolt holes for damaged threads and the splined surfaces on the crankshaft sprocket for any apparent damage. If any of the components are scored, scratched or worn, renew the entire oil pump assembly. There are no serviceable parts currently available.

REFITTING

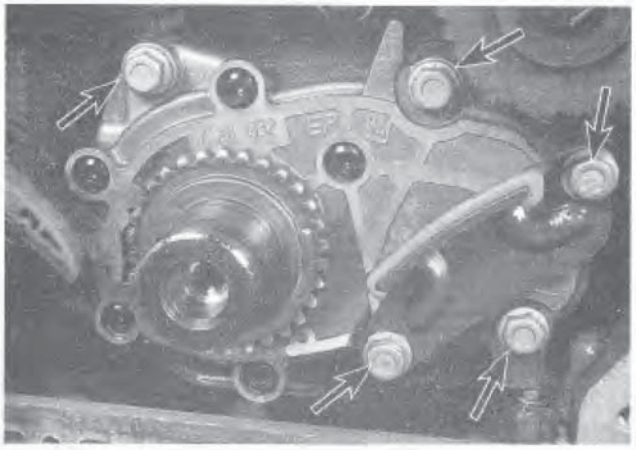
4 If re-using oil pump, assemble the pressure relief valve components and the rotors to the oil pump housing. Prior to installing the cover, prime the pump by pouring clean motor oil between the rotors. Install the cover and tighten the retaining bolts.

5 Position the oil pump over the end of the crankshaft and align the teeth on the crankshaft sprocket with the teeth on the oil pump drive gear. Make sure the pump is fully seated against the block.

6 Refit the oil pump mounting bolts and tighten them to the torque listed in this Chapter's Specifications.

7 The remainder of refitting is the reverse of removal.

8 Add oil and coolant as necessary. Run the engine and check for oil and coolant leaks. Also check the oil pressure as described in Chapter 2E.



15.2 Oil pump retaining bolts

16 Flywheel/driveplate - removal and refitting

The flywheel/driveplate renewal for the Alloytec V6 engine is identical to the flywheel/driveplate renewal procedure for the 3.8L V6 engines. Refer to Chapter 2 Part A for the procedure and use the torque figures in this Chapter's Specifications.

Note: *New bolts must be used when re-installing the flywheel/driveplate assembly.*

17 Rear main oil seal – renewal

Refer to illustrations 17.4 and 17.7

Note: *At the time of publication, the rear main oil seal is supplied as an assembly consisting of the oil seal and housing. To renew this it is necessary to remove the engine and engine sump. Over time the seal may become available separately. This may negate the need to remove the engine to change the seal allowing it to be replaced after removing the transmission and then removing the drive plate/flywheel.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

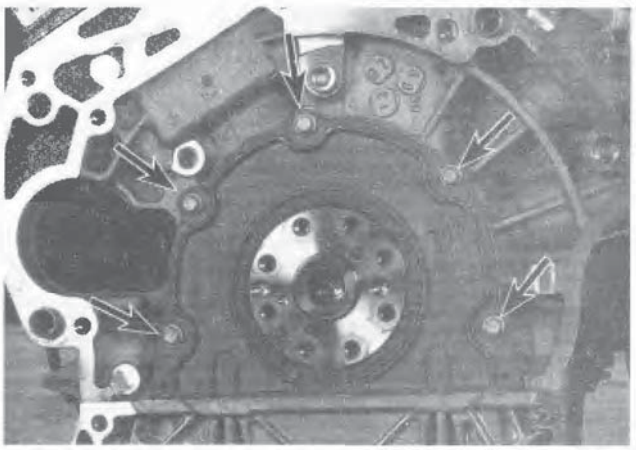
2 Remove the engine assembly from the vehicle (see Chapter 2E).

3 Remove the flywheel/driveplate (see Section 16), and the sump (see Section 14).

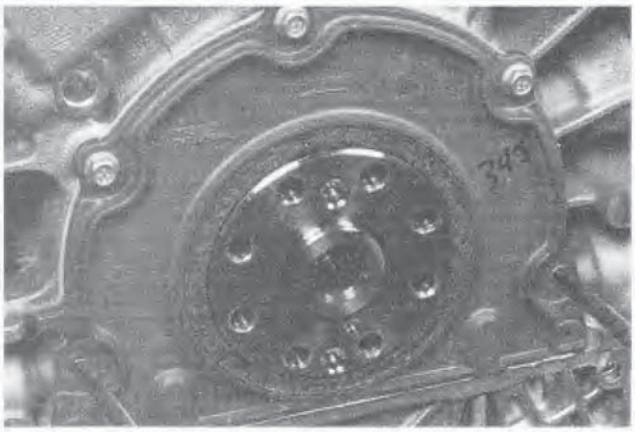
4 Remove the retaining bolts and remove the seal housing from the engine (see illustration). It may be necessary to use a knife to cut the sealant away from the joint between the rear main oil seal housing and the cylinder block.

Caution: *Use care not to scratch the machined faces of the cylinder block, rear main seal housing or sump when scraping old gasket material from components.*

5 Thoroughly clean the mounting surfaces of the sump, rear main oil seal housing and engine block of old gasket mate-



17.4 Rear main oil seal housing bolts



17.7 Alignment dowels fitted to the rear main oil seal housing bolt holes

rial and sealer. Wipe the gasket surfaces clean with a rag soaked in lacquer thinner, acetone or brake system cleaner.

6 If the seal is supplied separate to the seal housing, note the installed position of the old seal before tapping it out using a small punch or a seal removal tool. Lubricate the outside diameter of the seal and fit the seal over the seal housing. Make sure the lip of the seal points toward the engine. Preferably, a seal fitting tool (available at most auto parts stores) should be used to press the new seal back into place. If the proper seal fitting tool is unavailable, use a large socket, section of pipe or a blunt tool and carefully drive the new seal squarely into the seal bore to the same position that the original seal held.

7 Install two threaded dowel pins to the cylinder block to allow for correct rear main oil seal housing alignment (see illustration).

8 Apply a 3mm wide bead of oxygen sensor safe RTV sealant around the mating face of the rear main oil seal housing, passing the sealant on the inside of the bolt holes. Slide the seal over the crankshaft and the dowel pins and tighten the upper bolts finger-tight.

Note: The new rear main oil seal and housing assembly is supplied with a seal protector on the inside running face of the oil seal. Leave this in place until the housing is in position.

9 Remove the dowel pins and install the remaining rear main oil seal housing bolts. Tighten the bolts to the torque listed in this Chapter's Specifications, then remove the seal protector.

10 Refit the sump (see Section 14) and flywheel/driveplate (see Section 16).

11 The remainder of refitting is the reverse of removal.

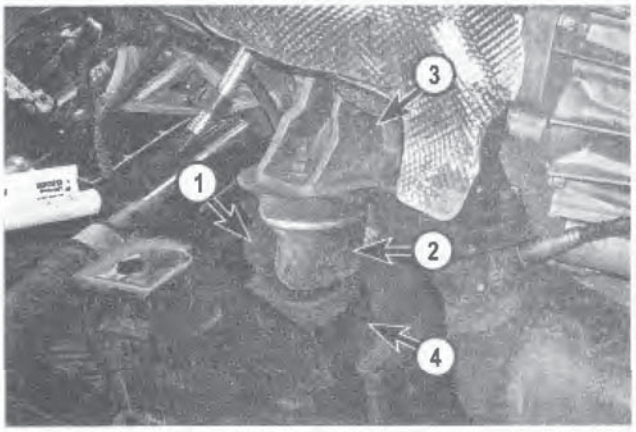
12 Add oil and coolant as necessary. Run the engine and check for oil and coolant leaks. Also check the oil pressure as described in Chapter 2E.

18 Engine mounts - check and renewal

1 Engine mounts seldom require attention, but broken or deteriorated mounts should be renewed immediately or the added strain placed on the driveline components may cause damage.

CHECK

2 During the check, the engine must be raised slightly to remove the weight from the mounts.



18.10 LH engine mount components

1	*Engine mount*	*3*	*Engine bracket*
2	*Heat shield*	*4*	*Crossmember*

3 Raise the vehicle and support it securely on jackstands, then position the jack under the engine sump. Place a large block of wood between the jack head and the sump, then carefully raise the engine just enough to take the weight off the mounts. Do not use the jack to support the entire weight of the engine.

4 Check the mounts to see if the rubber is cracked, hardened or separated from the metal plates. Sometimes the rubber will split right down the centre.

5 Check for relative movement between the mount plates and the engine or frame (use a large screwdriver or prise bar to attempt to move the mounts). If movement is noted, check the tightness of the mount fasteners first before condemning the mounts. Usually when engine mounts are broken, they are very obvious as the engine will easily move away from the mount when pried or under load.

RENEWAL

Refer to illustration 18.10

6 Disconnect the cable from the negative terminal of the battery, then raise the vehicle and support it securely on jackstands.

Caution: On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).

7 Remove the exhaust manifold (see Section 8) from the side of the engine that the mount is being renewed.

8 Working below the vehicle, remove the engine mount to front suspension cradle nut and then the engine mount to engine bracket nut.

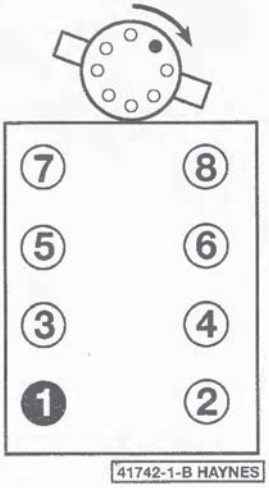
9 Attach an engine hoist to the top of the engine for lifting; do not use a jack under the sump to support the entire weight of the engine or the oil pump pick-up could be damaged.

10 Raise the engine slightly until the engine mount can be moved by hand. Unbolt the engine bracket from the engine block and remove it and the engine mount from the vehicle (see illustration). Separate the mount from the engine bracket.

11 Refitting is the reverse of removal. Tighten all bolts and nuts to the torque listed in this Chapter's Specifications.

Chapter 2
Engine
Part C. 5.0 litre V8 engine

Contents



Cylinder and spark plug wire terminal locations
The blackened terminal shown on the distributor cap indicates the Number One spark plug wire position

Specifications

General

Cylinder numbers (drivebelt end-to-transmission end)	
Left bank	2-4-6-8
Right bank	1-3-5-7
Firing order	1-2-7-8-4-5-6-3

Camshaft

Lobe lift	6.49 to 6.75 mm
Bearing journal diameter	
No.1 and 2	47.960 to 47.978 mm
No. 3 and 4	47.452 to 47.478
No. 5	40.107 to 40.132 mm
Bearing clearance	
New	0.04 to 0.09 mm
Maximum allowed	0.14 mm
Endplay	0.051 to 0.356 mm
Bend limit	0.05 mm

Oil pump

Gear backlash	0.2286 to 0.3810 mm
Gear protrusion from housing	0.051 to 0.153 mm

Torque specifications

	Nm
Camshaft sprocket and fuel pump eccentric bolt	61 to 74
Camshaft thrust plate (locator) bolt	68 to 81
Crankshaft balancer-to-crankshaft bolt, minimum	190
Crankshaft pulley to balancer bolts	22 to 28
Cylinder head bolts, in sequence	
Step 1	50 to 55
Step 2	77 to 83
Exhaust manifold-to-cylinder head bolts/studs	20 to 28
Exhaust pipe to exhaust manifold nuts	15 to 35
Flywheel/driveplate-to-crankshaft bolts	81 to 88
Front cover bolts	23 to 30
Inlet manifold-to-cylinder head bolts, in sequence	
Step 1	12 to 17
Step 2	34 to 41
Motor mount to bracket nuts	20 to 28
Motor mount bolts (all others)	34 to 46
Sump to block bolts	8 to 10
Oil pump to block bolts	23 to 30
Oil pump regulator plug	34 to 41
Oil filter adapter to oil pump bolts	17 to 22
Oil pump	
Cover-screws	5 to 8
Pick-up tube to block bolts	8 to 10
Rocker arm pivot bolts	24 to 32
Valve cover bolts	3 to 6

1 General information

This Part of Chapter 2 is devoted to in-vehicle repair procedures for the 5.0 litre V8 engine.

Information concerning camshaft bearings and engine removal and refitting, as well as engine block and cylinder head overhaul, is in Part E of this Chapter.

The following repair procedures are based on the assumption the engine is refitted in the vehicle. If the engine has been removed from the vehicle and mounted on a stand, many of the Steps included in this Part of Chapter 2 will not apply.

The Specifications included in this Part of Chapter 2 apply only to the procedures in this Part. The Specifications necessary for rebuilding the block and cylinder heads are found in Part E.

2 Repair operations possible with the engine in the vehicle

Many major repair operations can be accomplished without removing the engine from the vehicle.

Clean the engine compartment and the exterior of the engine with some type of pressure washer before any work is done. A clean engine will make the job easier and will help keep dirt out of the internal areas of the engine.

Depending on the components involved, it may be a good idea to remove the bonnet to improve access to the engine as repairs are performed (refer to Chapter 11 if necessary).

Exterior engine components such as the inlet and exhaust manifolds, the sump, the oil pump, the water pump, the starter motor, the alternator and the fuel injection system can be removed for repair with the engine in place. The timing chain and sprockets, crankshaft oil seals and cylinder head gaskets are all accessible with the engine in place.

Since the cylinder heads can be removed without pulling the engine, valve component servicing can also be accomplished with the engine in the vehicle, although it is difficult.

In extreme cases caused by a lack of necessary equipment, repair or renewal of piston rings, pistons, connecting rods and rod bearings is possible with the engine in the vehicle. However, this practice is not recommended because of the cleaning and preparation work that must be done to the components involved.

3 Top Dead Centre (TDC) for number one piston - locating

Refer to illustrations 3.6 and 3.7

1 Top Dead Centre (TDC) is the highest point in the cylinder that each piston reaches as it travels up and down when the crankshaft turns. Each piston reaches TDC on the compression stroke and again on the exhaust stroke, but TDC generally refers to piston position on the compression stroke. The timing marks on the crankshaft balancer refited on the front of the crankshaft are referenced to the number one piston at TDC on the compression stroke.

2 Positioning the piston(s) at TDC is an essential part of many procedures such as rocker arm removal, timing chain and sprocket replacement and distributor removal.

3 In order to bring any piston to TDC, the crankshaft must be rotated. The preferred method is to turn the crankshaft with a large socket and breaker bar attached to the crankshaft balancer bolt threaded into the front of the crankshaft. When looking at the front of the engine, normal crankshaft rotation is clockwise.

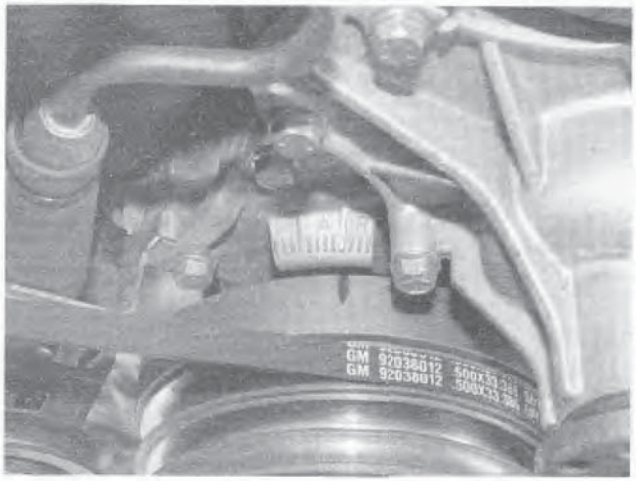
Warning: *Before beginning this procedure, be sure to place the transmission in Neutral or Park, apply the parking brake and place the ignition key in the Lock position.*

4 Apply a mark on the distributor housing directly below the number one spark plug wire terminal on the distributor cap.

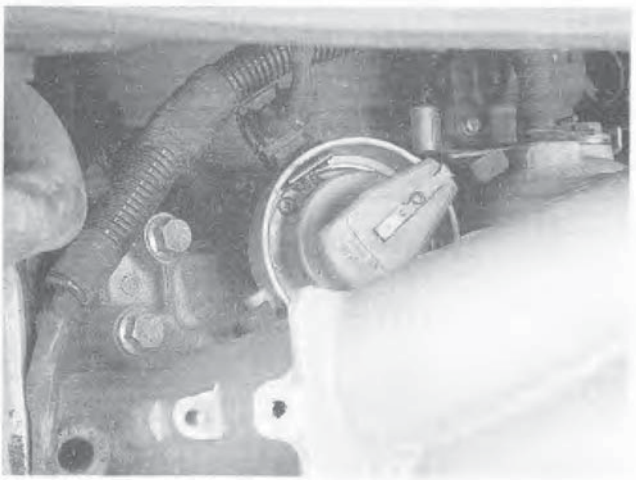
5 Remove the distributor cap as described in Chapter 1.

6 Rotate the crankshaft until the groove on the crankshaft balancer is aligned with the zero mark on the timing indicator scale (see illustration).

7 The rotor should now be pointing directly at the mark on the distributor housing (see illustration). If it isn't, the piston may be at TDC on cylinder number 4, rotate the crankshaft one complete turn (360 degrees) clockwise. The rotor should



3.6 When the engine is at top dead centre, the mark on the crankshaft balancer will line up with the zero mark (the long line between A and R) mark on the timing indicator



3.7 When the engine is at TDC the distributor rotor will point at the terminal for cylinder number 1

now be pointing at the mark. When the rotor is pointing at the number one spark plug wire terminal in the distributor cap (which is indicated by the mark on the housing) and the ignition timing marks are aligned, the number one piston is at TDC on the compression stroke.

8 After the number one piston has been positioned at TDC on the compression stroke, TDC for any of the remaining cylinders can be located by turning the crankshaft 90 degrees at a time and following the firing order (refer to the Specifications).

4 Valve covers - removal and refitting

Refer to illustration 4.6

1 Disconnect the negative battery cable from the battery.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*

2 Remove the spark plug wires from the spark plugs and clips. Tag and number each wire before removal to ensure correct refitting.

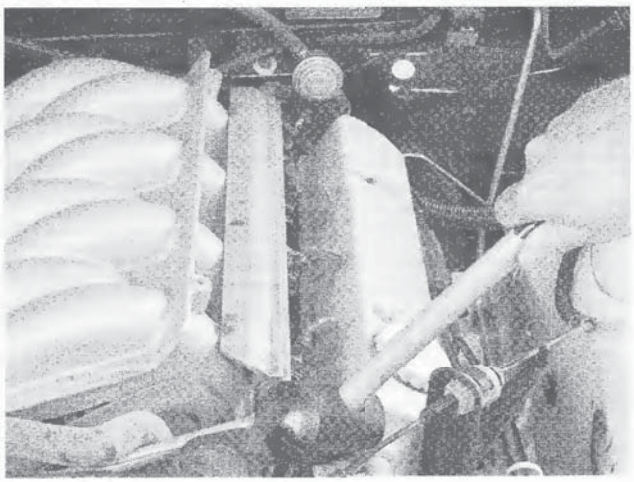
3 Remove the engine covers from the fuel rails and the throttle body. Set them carefully aside where they will not be damaged.

4 Disconnect the PCV hoses from the valve covers.

5 Remove the valve cover mounting bolts. As with the trim cover bolts, these are socket head bolts. Note the locations of the bolts and the spark plug wire brackets as they are removed.

6 Detach the valve covers (see illustration).

> ***Note:*** *If the covers stick to the cylinder head, use a soft-face hammer to dislodge them. Do not attempt to prise the covers off.*



4.6 If the valve covers are stuck, tap on them with a rubber mallet or a hammer and a block of wood. Do not prise on them

REFITTING

7 The mating surfaces of the cylinder head and valve cover must be perfectly clean when the covers are refitted. Be extra careful not to nick or gouge the mating surfaces if you use a scraper.

8 Position a new gasket into the valve cover.

9 Place the valve cover and new gasket in position, then refit the bolts. Make sure to use new seals on the bolts which secure the centre of the valve cover.

10 Tighten the bolts/nuts to the torque listed in this Chapter's Specifications.

11 Complete the refitting by reversing the removal procedure.

12 Start the engine and check for oil leaks at the valve cover-to-cylinder head joints.

5 Rocker arms, pivots and pushrods - removal, inspection and refitting

REMOVAL

1 Refer to Section 4 and remove the valve covers from the cylinder heads.

2 Loosen the rocker arm pivot bolts one at a time and detach the rocker arms, bolts and pivots. Keep track of the rocker arm and the pivot positions, since they must be returned to the same locations. Store each set of rocker components separately in a marked plastic bag or in a labeled rack to ensure that they're refitted in their original locations.

3 Remove the pushrods, label and store them separately to make sure they don't get mixed up during refitting.

INSPECTION

4 Check each rocker arm for wear, cracks and other damage, especially where the pushrods and valve stems contact the rocker arm.

5 Check the pivot seat in each rocker arm and the pivot faces. Look for galling, stress cracks and unusual wear patterns. If the rocker arms are worn or damaged, renew them with new ones and fit new pivots as well.

6 Make sure the hole at the pushrod end of each rocker arm is open.

7 Inspect the pushrods for cracks and excessive wear at the ends. Roll each pushrod across a piece of plate glass to see if it's bent (if it wobbles, it's bent).

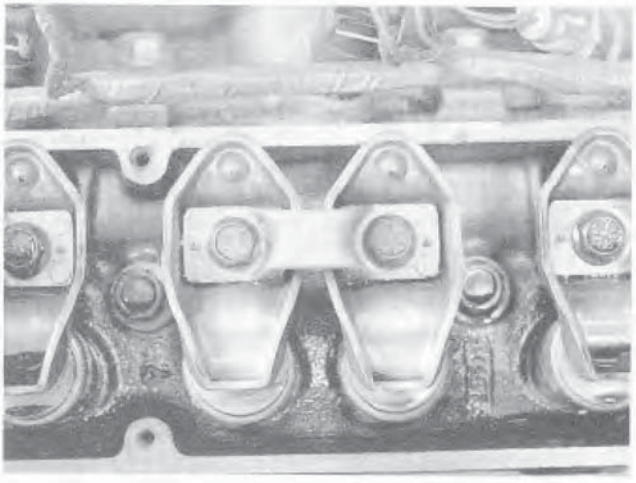
REFITTING

Refer to illustration 5.11

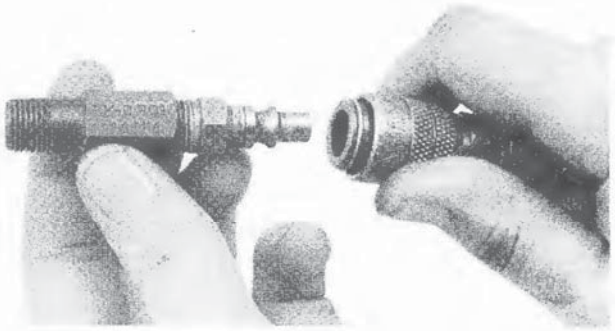
8 Lubricate the lower end of each pushrod with clean engine oil or moly-base grease and refit them in their original locations. Make sure each pushrod seats completely in the lifter socket.

9 Apply moly-base grease to the ends of the valve stems, the upper ends of the pushrods and to the pivot faces to prevent damage to the mating surfaces before engine oil pressure builds up.

10 Rotate the engine to the number one cylinder TDC position on the compression stroke (refer to Section 3). The pushrods for cylinder 1 must both be in the fully lowered position. If they are both raised slightly, rotate the engine 360 degrees so that the crankshaft timing pointer is at zero and the



5.11 The arrow on each rocker arm pivot must point towards the centre of the engine



6.4 This is what the air hose adapter that threads into the spark plug hole looks like - they're commonly available from auto parts stores

distributor rotor is pointing at the terminal for number one cylinder.

11 Refit the rocker assembly for number one cylinder.

> ***Note:*** *The small arrows cast into each rocker pivot must point towards the centre of the engine (see illustration).*

Tighten the bolts to the torque listed in this Chapter's Specifications.

12 Rotate the crankshaft 90 degrees clockwise (in the direction of normal rotation). Perform the same refitting procedure to the next cylinder in the firing order (number 2 in this case). Repeat this operation for the remaining cylinders in the sequence of the firing order. Both pushrods must be fully retracted as you refit each rocker assembly.

13 Refit the valve covers (see Section 4).

14 The remainder of the refitting is the reverse of removal.

6 Valve springs, retainers and seals - renewal

Refer to illustrations 6.4, 6.7 and 6.16

> ***Note:*** *Broken valve springs and defective valve stem seals can be refited without removing the cylinder heads. Two special tools and a compressed air source are normally required to perform this operation, so read through this Section carefully and rent or buy the tools before beginning the job.*

1 Refer to Section 4 and remove the valve cover from the affected cylinder head. If all of the valve stem seals are being renewed, remove both valve covers.

2 Remove the spark plug from the cylinder which has the defective component. If all of the valve stem seals are being renewed, all of the spark plugs should be removed.

3 Turn the crankshaft until the piston in the affected cylinder is at Top Dead Centre on the compression stroke (refer to Section 3 for instructions). If you're renewing all of the valve stem seals, begin with cylinder number one and work on the valves for one cylinder at a time. Move from cylinder-to-cylinder following the firing order sequence.

4 Thread an adapter into the spark plug hole (see illustration) and connect an air hose from a compressed air source to it. Most auto parts stores can supply the air hose adapter.

> ***Note:*** *Many cylinder compression gauges utilize a screw-in fitting that may work with your air hose quick-disconnect fitting.*

5 Remove the bolts, pivot and rocker arms for the cylinder with the defective part and pull out the pushrod (see Section 5). If all of the valve stem seals are being renewed, all of the rocker arms and pushrods should be removed.

6 Apply compressed air to the cylinder. The valves should be held in place by the air pressure.

> ***Warning:*** *If the cylinder isn't exactly at TDC, air pressure may cause the engine to rotate, do not leave a socket or spanner on the balancer bolt, or you may be injured by the tool.*

7 Stuff shop rags into the cylinder head holes above and below the valves to prevent parts and tools from falling into the engine, then use a valve spring compressor to compress the spring. Remove the collets with small needle-nose pliers or a magnet (see illustration).

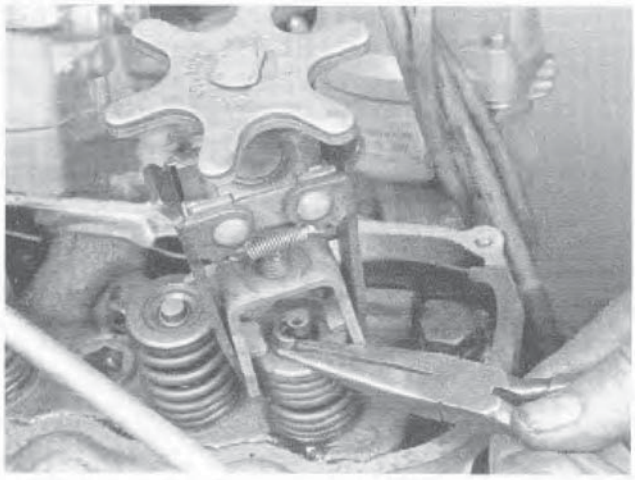
8 Remove the spring retainer, oil shield and valve spring, then remove the O-ring seal.

> ***Note:*** *If air pressure fails to hold the valve in the closed position during this operation, the valve face or seat is probably damaged. If so, the cylinder head will have to be removed for additional repair operations.*

9 Wrap a rubber band or tape around the top of the valve stem so the valve won't fall into the combustion chamber, then release the air pressure.

10 Inspect the valve stem for damage. Rotate the valve in the guide and check the end for eccentric movement, which would indicate that the valve is bent.

11 Move the valve up-and-down in the guide and make sure it doesn't bind. If the valve stem binds, either the valve is bent



6.7 After compressing the valve spring, use needle nose pliers to extract the collets

6.16 Apply a small dab of grease to each collet as shown here before refitting - it'll hold them in place on the valve stem as the spring is released

or the guide is damaged. In either case, the head will have to be removed for repair.

12 Reapply air pressure to the cylinder to retain the valve in the closed position, then remove the tape or rubber band from the valve stem.

13 Lubricate the valve stem with clean engine oil and fit a new valve seal.

Caution: *Make certain that the seal is not refitted in the groove used by the retainer.*

Note: *The factory O-ring seal only controls oil running down the valve stem from above. There are aftermarket seals which can be used in addition to the factory O-ring seal to assist in oil control at the valve guide boss. Consult an auto supply specialist if you feel this is necessary.*

14 Refit the spring in position over the valve.

15 Refit the valve spring retainer and compress the valve spring.

16 Position the collets in the upper groove. Apply a small dab of grease to the inside of each collet to hold it in place if necessary (see illustration). Remove the force from the spring tool and make sure the collets are seated.

17 Disconnect the air hose and remove the adapter from the spark plug hole.

18 Refit the pushrod(s) and rocker arms.

19 Refit the spark plug(s) and connect the wire(s).

20 Refer to Section 4 and refit the valve cover(s).

21 Start and run the engine, then check for oil leaks and unusual sounds coming from the valve cover area.

7 Inlet manifold- removal and refitting

REMOVAL

1 Relieve the fuel system pressure (see Chapter 4).

2 Disconnect the negative battery cable from the battery.

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*

3 Disconnect the fuel supply and return lines at the firewall. Do not disconnect them at the fuel rail. Label the hoses to avoid confusion later.

Note 1: *The supply tube has a white tag attached.*

Note 2: *Refer to Chapter 4 for this procedure. A special tool is required to disconnect the quick connect fuel line fittings.*

4 Drain the coolant from the engine (refer to Chapter 1).

5 Remove the upper engine trim covers.

6 Disconnect the radiator hose from the thermostat housing. Disconnect the coolant bypass hose from the water pump and the inlet manifold.

7 Disconnect the heater hoses and tie them out of the way.

8 Disconnect the inlet air supply duct from the throttle body.

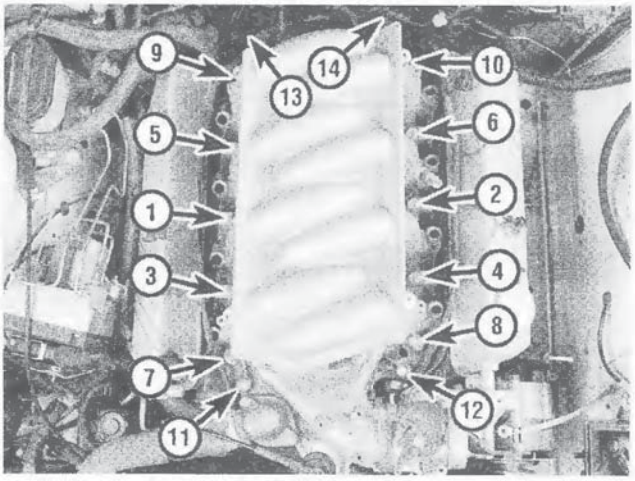
9 Label and then disconnect all other interfering hoses. These include the PCV hoses, the MAP sensor hose, the brake booster vacuum hose and the heater control hoses. Label and disconnect the EVAP canister hoses from the throttle body.

10 Disconnect the electrical wiring from the throttle body. Disconnect the MAT sensor wiring harness from the number 6 cylinder sensor. Disconnect the wiring harnesses from the temperature sensors at the front of the inlet manifold.

11 Disconnect each fuel injector wiring connector by sliding out the wire clip and pulling the harness from the injector.

12 Disconnect the throttle and cruise control cables from the throttle body. Remove the cable bracket and move it aside.

13 Remove the ignition coil assembly.



7.20 Be certain to tighten the inlet manifold bolts in this sequence

14 Remove the manifold mounting bolts, and separate the manifold from the engine. Do not prise between the manifold and heads, as damage to the gasket sealing surfaces may result. If you're fitting a new manifold, transfer all fittings, fuel rail, injectors, throttle body and sensors to the new manifold.

REFITTING

Refer to illustration 7.20

> ***Note:*** *The mating surfaces of the cylinder heads, block and manifold must be perfectly clean when the manifold is refitted. Gasket removal solvents are available at most auto parts stores and may be helpful when removing old gasket material that's stuck to the heads and manifold (since the manifold is made of aluminium, aggressive scraping can cause damage). Be sure to follow the directions printed on the container.*

15 Use a gasket scraper to remove all traces of sealant and old gasket material, then clean the mating surfaces with lacquer thinner or acetone.

> ***Note:*** *If there is any oil residue or gasket sealer left on the front and rear block surfaces, then the rubber seals may slide out of position.*

If there's old sealant or oil on the mating surfaces when the manifold is refitted, oil or vacuum leaks may develop. Use a vacuum cleaner to remove any gasket material that falls into the inlet ports or the lifter valley.

16 Use a tap of the correct size to chase the threads in the bolt holes, then use compressed air (if available) to remove the debris from the holes.

> ***Warning:*** *Wear safety glasses or a face shield to protect your eyes when using compressed air.*

17 Apply a 3 mm bead of RTV sealant around the cylinder head water passages.

> ***Caution:*** *Refit the manifold within 15 minutes of applying the RTV sealant.*

18 Fit new gaskets, holding them from slipping with the supplied plastic inserts. The R on each gasket must be at the rear of the engine.

> ***Note:*** *Apply a dab of sealing compound to the four points at which the rubber end seals contact the side gaskets. The seals must engage the slots in the gaskets. The front rubber seal must be positioned so that the single lug which protrudes faces forward. The front and rear seals must be refitted without sealer of any kind.*

19 Carefully lower the manifold into place. Refit the bolts finger tight.

20 Tighten the mounting bolts in two steps in the recommended sequence (see illustration) until they're all at the final torque listed in this Chapter's Specifications.

21 Refit the remaining components in the reverse order of removal.

22 Change the oil and filter and fill the cooling system (see Chapter 1). Start the engine and check for oil and vacuum leaks.

8 Exhaust manifolds - removal and refitting

> ***Warning:*** *Allow the engine to cool completely before beginning this procedure.*

> ***Note:*** *Exhaust system fasteners are frequently difficult to remove - they get "seized" in place because of the heating/cooling cycle to which they're constantly exposed. To ease removal, apply penetrating oil to the threads of all exhaust manifold and exhaust pipe fasteners and allow it to soak in.*

REMOVAL

Refer to illustration 8.7

1 Disconnect the negative battery cable.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*

2 Remove the spark plugs (refer to Chapter 1).

3 Disconnect the wiring to the oxygen sensor if it interferes with removal.

4 Raise the vehicle and support it securely on jackstands.

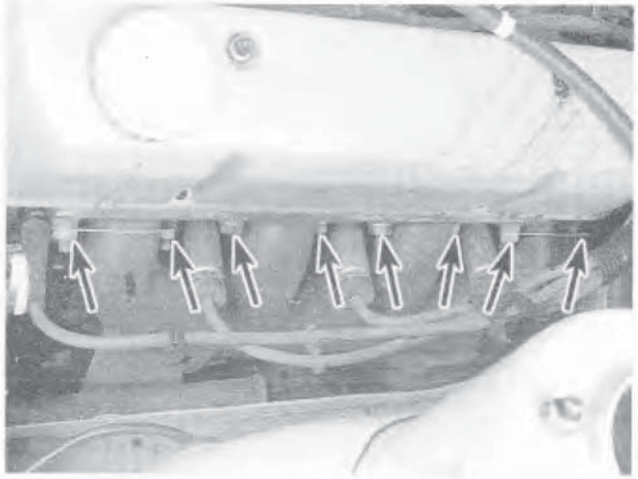
5 Remove the nuts on each pipe that secure the exhaust pipe to the exhaust manifold. Pull the exhaust pipes free.

6 Lower the vehicle. Remove the nuts and the lock plates, if used, from the manifold.

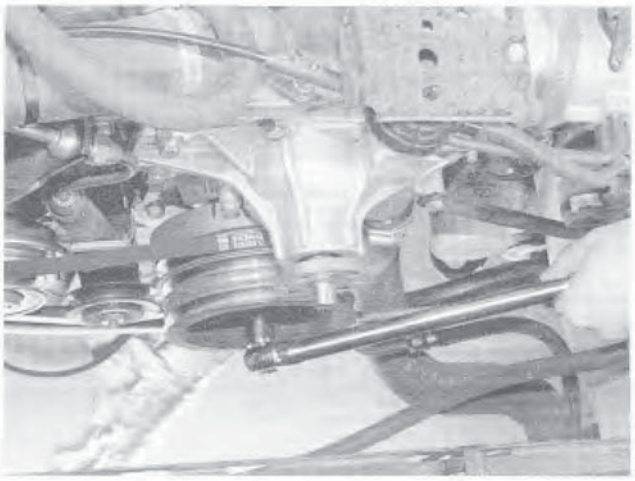
7 Remove the exhaust manifold fasteners and remove the manifold (see illustration).

REFITTING

8 Clean the mating surfaces of the manifold and cylinder head to remove all traces of old gasket material, then check the



8.7 Exhaust manifold retaining bolts and nuts (arrows)



9.8 Use a long breaker bar to loosen the balancer bolt. It is very tight

manifold for warpage and cracks. Use a precision machinist's straightedge to inspect the surface. If the manifold requires it, take it to an automotive machine shop for minor resurfacing.

9 Place the manifold in position and apply anti-seize to the threads of all fasteners. Refit the bolts/nuts finger tight.

10 Starting in the middle and working out toward the ends, tighten the mounting bolts/nuts a little at a time until all are at the torque listed in this Chapter's Specifications. Apply anti-seize to the threads of the oxygen sensor if it was removed.

11 Refit the remaining components in the reverse order of removal.

12 Refer to Chapter 1 and refill the cooling system.

13 Start the engine and check for exhaust leaks between the manifold and cylinder head and between the manifold and exhaust pipe.

9 Crankshaft balancer and front oil seal - renewal

BALANCER REMOVAL

Refer to illustration 9.8

1 Disconnect the negative cable from the battery.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*

2 Remove the drivebelts (see Chapter 1).

3 Remove the electric cooling fan and shroud assembly for access, if necessary (refer to Chapter 3).

4 Raise the vehicle and support it securely on jackstands.

5 Remove the balancer bolt while loosening the bolt. The crankshaft must be held from turning. Follow one of the following methods for locking the engine.

6 If the vehicle has a manual transmission, block the rear wheels, apply the parking brake and put it in high gear.

7 On vehicles equipped with an automatic transmission, remove the starter (refer to Chapter 5) and insert a long lever through the starter hole to lock the driveplate.

8 The balancer bolt is normally very tight, so use a long breaker bar and a six-point socket (see illustration). Remove the balancer. If necessary, use a puller to remove it. If you're replacing the front oil seal, remove the Woodruff key from the end of the crankshaft.

9 If there's a groove worn into the seal contact surface on the crankshaft balancer, sleeves are available that fit over the groove, restoring the contact surface to like-new condition. These sleeves are sometimes included with the seal kit. Check with your parts supplier for details.

SEAL RENEWAL

10 Prise the old oil seal out with a seal removal tool or a screwdriver. Be very careful not to nick or otherwise damage the crankshaft in the process.

11 Apply a thin coat of RTV-type sealant to the outer edge of the new seal. Lubricate the seal lip with clean engine oil.

12 Place the seal squarely in position in the bore and press it into place with a seal driver. The open portion of the seal must face inwards. Make sure the seal enters the bore squarely and seats completely.

13 If a seal driver is unavailable, carefully guide the seal into place with a large socket or piece of pipe and a hammer. The outer diameter of the socket or pipe should be the same size as the seal outer diameter.

14 Refitting is the reverse of removal. Align the keyway with the crankshaft key. Be sure to apply engine oil to the seal contact surface on the back side of the balancer (if it isn't lubricated, the seal lip could be damaged and oil leakage would result).

15 Apply a very small amount of engine oil to the crankshaft snout and to the key. Refit the crankshaft balancer. Tighten the crankshaft balancer bolt to the torque listed in this Chapter's Specifications.

16 Refit the remaining parts in the reverse order of removal.

17 Start the engine and check for oil leaks at the seal.

10 Front cover, timing chain and sprockets - removal and refitting

FRONT COVER REMOVAL

1 Disconnect the negative battery cable from the battery.

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*

2 Position the engine with the number one piston at TDC on the compression stroke (refer to Section 3).

3 Remove the crankshaft balancer (see Section 9).

4 Drain the coolant. Refer to Chapter 1.

5 Remove the alternator and the braces.

6 Remove the heater hose and the bypass hose from the water pump.

7 Unbolt the air conditioning compressor bracket from the engine (refer to Chapter 3). Move the assembly aside and secure it without disconnecting the hoses.

8 Set the parking brake and put the transmission in Park. Raise the front of the vehicle and support it securely on jackstands.

9 Remove the sump bolts and allow the sump to rest on the crossmember.

> ***Note:*** *It is possible in some cases, to simply remove the bolts securing the sump to the front cover and then loosen the rest of the sump bolts near the front of the engine. The front of the sump can then be gently pried downwards with two screwdrivers, allowing the front cover to be removed. If this method is used, take care to carefully clean and then apply sealer to all sealing points upon refitting.*

10 Remove the front cover-to-engine block bolts. Remove the front cover along with the water pump.

CHAIN AND SPROCKET REMOVAL

11 The timing chain should be renewed with a new one if it has become excessively loose. Failure to renew the timing chain may result in erratic engine performance, loss of power and lowered fuel efficiency.

> ***Note:*** *New timing chains are generally sold as a set, with the new chain and new camshaft and crankshaft gears; do not attempt to renew parts individually.*

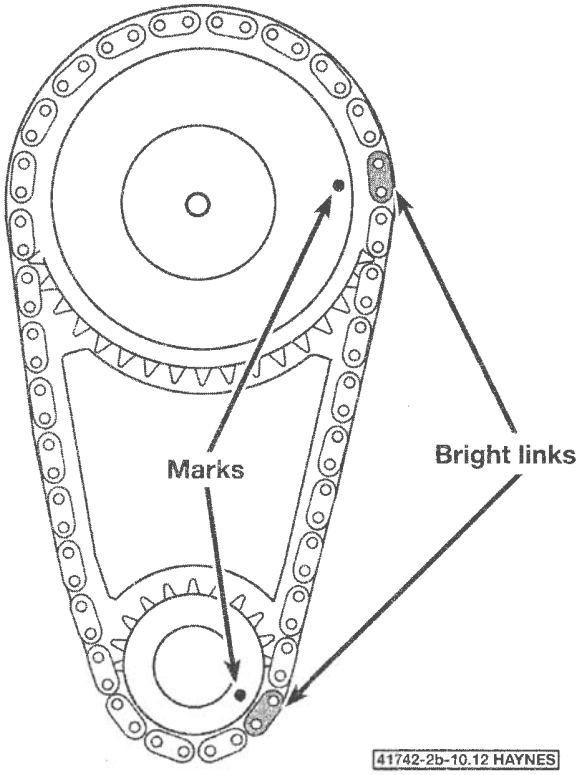
12 If the number one piston was not properly set to TDC on the compression stroke in Step 2, do so at this time.

13 Remove the bolt securing the camshaft sprocket to the camshaft. Remove the camshaft sprocket and the chain.

> ***Caution:*** *Do not rotate the crankshaft after removing the timing chain.*

14 Slide or prise the crankshaft sprocket from the crankshaft.

15 Use a gasket scraper to remove all traces of old gasket material and sealant from the cover and engine block. Be careful not to nick or gouge the cover. Clean the gasket sealing surfaces with lacquer thinner or acetone.



10.18 The bright-plated links on the timing chain must mate with the marks on the timing sprockets. The sprockets will be in this position when the engine is at TDC

16 Clean the timing chain components with solvent and dry them with compressed air (if available).

> ***Warning:*** *Wear eye protection.*

17 Inspect the components for wear and damage. Look for teeth that are deformed, chipped, pitted, polished or discoloured.

REFITTING

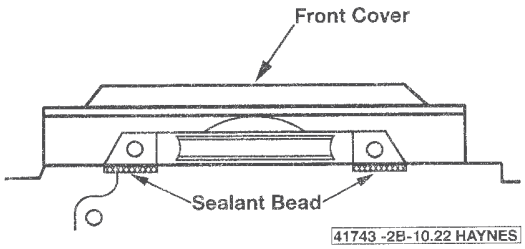
Refer to illustrations 10.18 and 10.21

> ***Note:*** *If the crankshaft has been disturbed, fit the new sprocket temporarily and turn the crankshaft until the mark on the crankshaft sprocket is at the four o'clock. If the camshaft was disturbed, fit the new sprocket temporarily and turn the camshaft until the timing mark is at three o'clock.*

18 Refit the crankshaft sprocket. Assemble the timing chain to the camshaft sprocket, then slip the sprocket and chain assembly onto the crankshaft sprocket with the timing marks aligned with the bright links of the timing chain (see illustration).

19 Apply Loctite 242 to the threads and refit the camshaft sprocket bolt. Tighten to the torque listed in this Chapter's Specifications.

20 Thoroughly clean all sealing surfaces of the sump, and front cover with acetone or lacquer thinner. Fit a new gasket.



10.21 Apply beads of sealant to the front cover where it meets the sump at these critical areas (arrows)

21 Apply a thin layer of RTV sealant to both sides of the new front cover gasket, then position the gasket on the engine block. Apply a bead of sealer to the areas where the front cover meets the sump (see illustration).

22 Place the front cover and water pump onto the engine. Tighten the bolts to the torque listed in this Chapter's Specifications.

23 Follow a criss-cross pattern when tightening the bolts and work up to the torque listed in this Chapter's Specifications in three steps to avoid warping the cover.

24 The remainder of refitting is the reverse of removal.

25 Add oil and coolant as required, start the engine and check for leaks. If the old timing chain was severely stretched, it will be necessary to check the ignition timing.

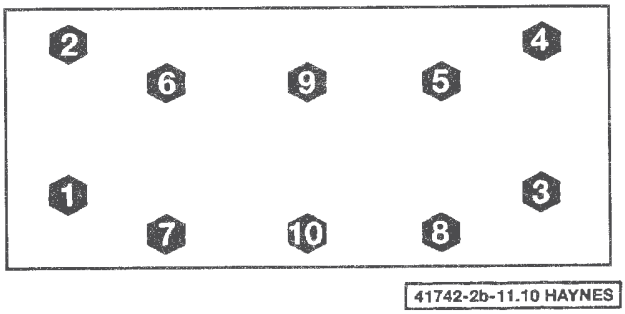
11 Cylinder heads - removal and refitting

REMOVAL

Refer to illustrations 11.10 and 11.20

1 Disconnect the negative battery cable at the battery.

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*



11.10 Head bolt loosening sequence

2 Disconnect the spark plug wires and remove the spark plugs (see Chapter 1). Be sure to label the plug wires to simplify refitting. Lay them out of the way.

3 Remove the valve covers (see Section 4).

4 Remove the rocker arms and pushrods (see Section 5).

5 Remove the inlet manifold as described in Section 7.

6 Disconnect all interfering wires, brackets and hoses from the cylinder head(s). Be sure to label them to simplify refitting.

7 Detach the exhaust manifold(s) from the cylinder head(s) being removed (see Section 8). It is not necessary to disconnect them from the exhaust pipes.

8 To remove the left cylinder head, remove the alternator and its brackets (refer to Chapter 5).

9 To remove the right head, unbolt the power steering pump from its bracket. Do not disconnect the hoses. Set the pump aside while keeping it upright. Remove the nuts securing the pump bracket to the cylinder head. Remove both brackets from the head.

10 Loosen the head bolts in 1/4-turn increments until they can be removed by hand. Start with the end bolts and work gradually towards the centre in the sequence shown (see illustration).

Note: *There is one socket-head bolt used on each cylinder head at the lower right corner.*

11 Lift the head off the engine. If resistance is felt, don't prise between the head and block as damage to the mating surfaces will result. Recheck for head bolts that may have been overlooked, then use a hammer and block of wood to tap the head and break the gasket seal. Be careful because there are locating dowels in the block which position each head. As a last resort, prise each head up at the rear corner only and be careful not to damage anything. After removal, place the head on blocks of wood to prevent damage to the gasket surfaces.

12 Refer to Chapter 2, Part E, for cylinder head disassembly, inspection and valve service procedures.

REFITTING

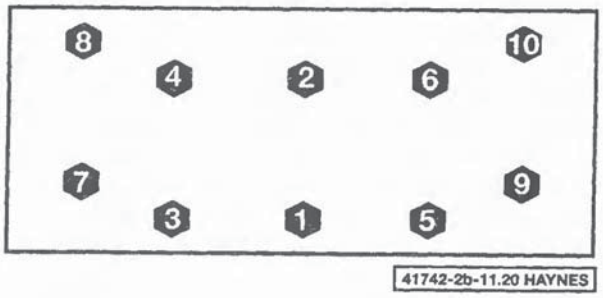
13 The mating surfaces of the cylinder heads and block must be perfectly clean when the heads are refitted.

14 Use a gasket scraper to remove all traces of carbon and old gasket material, then clean the mating surfaces with lacquer thinner or acetone. If there's oil on the mating surfaces when the heads are refitted, the gaskets may not seal correctly and leaks may develop. When working on the block, it's a good idea to cover the lifter valley with shop rags to keep debris out of the engine. Use a shop rag or vacuum cleaner to remove any debris that falls into the cylinders.

15 Check the block and head mating surfaces for nicks, deep scratches and other damage. If damage is slight, it can be removed with a file; if it's excessive, machining may be the only alternative.

16 Use a tap of the correct size to clean up the threads in the head bolt holes. Dirt, corrosion, sealant and damaged threads will affect torque readings.

17 Position the new gaskets over the dowel pins in the block. Most gaskets are marked TOP and have sealant lines on the upper surface. Verify that there are no blocked or unsealed passages caused by an improperly refitted gasket.



11.20 Head bolt tightening sequence

18 Carefully position the heads on the block without disturbing the gaskets.

19 Apply sealer to the threads of the bolts that go into the water passages. These include all bolts except the three inner bolts on the lower row. These three bolts should be lightly lubricated with engine oil.

20 Tighten the bolts to the torque listed in this Chapter's Specifications. Be certain to follow the proper tightening sequence (see illustration).

21 The remaining refitting steps are the reverse of removal.

22 Change the oil and filter (see Chapter 1).

12 Camshaft and lifters - removal, inspection and refitting

CAMSHAFT LOBE LIFT CHECK

1 To determine the extent of cam lobe wear, the lobe lift should be checked prior to camshaft removal. Refer to Section 4 and remove the valve covers.

2 Remove the rocker arms. Refer to Section 5.

3 Beginning with the number one cylinder. Mount a dial indicator on the engine and position the plunger against the top surface of the first pushrod (see illustration 12.3 in Part A of this Chapter). Rotate the engine by hand if necessary until you are sure that the lifter is on the lowest part (heel) of the cam.

4 Zero the dial indicator, then very slowly turn the crankshaft in the normal direction of rotation until the indicator needle rises and then stops and begins to move in the opposite direction. The point at which it stops indicates approximate maximum cam lobe lift.

5 Record this figure for future reference.

6 Repeat the check for the remaining valves.

7 After the check is complete, compare the results to the Specifications in this Chapter. If camshaft lobe lift is appreciably less than specified, cam lobe wear has occurred and a new camshaft should be refitted.

8 A noisy valve lifter can be isolated when the engine is idling. Hold a mechanic's stethoscope or a length of hose near the position of each valve while listening at the other end.

9 The most likely causes of noisy valve lifters are dirt trapped between the plunger and the lifter body or lack of oil flow, viscosity or pressure. Before condemning the lifters, we recommend checking the oil for fuel contamination, proper level, cleanliness and correct viscosity.

12.20 The roller must turn freely - check for wear and excessive play as well

LIFTER REMOVAL

10 Remove the valve cover(s) as described in Section 4.

11 Remove the rocker arms, pivots and pushrods (see Section 5).

12 Remove the inlet manifold as described in Section 7. Remove the guide retainer and lifter guides.

13 Before removing the lifters, arrange to store them in a clearly labeled box to ensure that they're refitted in their original locations. Remove the lifters and store them where they won't get dirty.

CAMSHAFT REMOVAL

14 To allow room for camshaft removal, the radiator and air conditioning condenser must be removed (see Chapter 3).

> ***Warning:*** *The air conditioning system is under high pressure. DO NOT loosen any fittings or remove any components until after the system has been discharged. Air conditioning refrigerant should be properly discharged into an approved recovery container at a dealership service department or an automotive air conditioning repair facility. Always wear eye protection when disconnecting air conditioning system fittings.*

15 Remove the timing chain front cover, the timing chain and camshaft sprocket (see Section 10). Remove the distributor (refer to Chapter 5). Remove the inlet manifold (see Section 7). Remove the lifters (see Steps 10 through 13).

16 Remove the locator which secures the front of the camshaft to the block.

17 Carefully and slowly pull the camshaft out. It may be helpful to put a long bolt into the front of the camshaft to act as a handle. Support the cam near the block so the lobes do not nick or gouge the bearings as the cam is withdrawn.

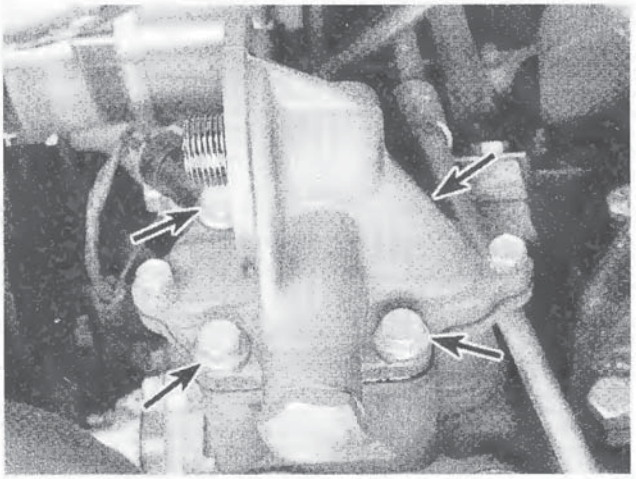
INSPECTION

Refer to illustration 12.20

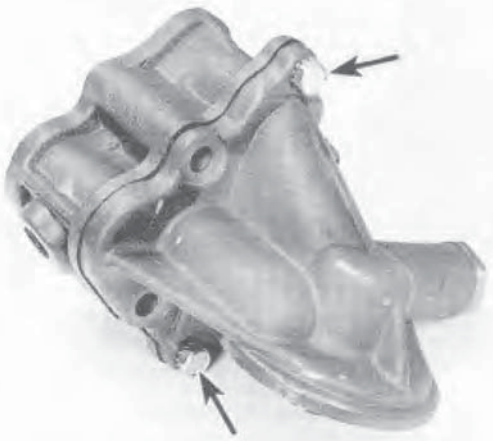
18 Parts for valve lifters are not available separately. Always fit new units if they are questionable The work required to remove them from the engine again if repair is unsuccessful outweighs any potential savings from repairing them.

19 Clean the lifters with solvent and dry them thoroughly without mixing them up. It is important that they be returned to their original locations.

> ***Caution:*** *Never fit used lifters with a new camshaft. If the camshaft is not damaged, new lifters may be fitted if necessary.*



13.4 There are four bolts (arrows) which secure the oil pump to the block. Remove only these bolts and then lift the pump off



13.5 Remove the remaining two bolts (arrows) which secure the housing of the pump to the pump cover

20 Check the lifters carefully for wear and damage (see illustration). The walls, the pushrod seat and the roller must be checked. If the lifter walls are damaged or worn (which is not very likely), inspect the lifter bores in the engine block as well. If the pushrod seats are worn, check the pushrod ends. If you are renewing the camshaft, you must renew all the lifters at the same time.

21 When refiting used lifters, make sure they're refited in their original bores. Soak new lifters in oil to remove trapped air. Coat all lifters with moly-base grease or engine assembly lube prior to refitting.

22 After the camshaft has been removed from the engine, cleaned with solvent and dried, inspect the bearing journals for uneven wear, pitting and evidence of seizure. If the journals are damaged, the bearing inserts in the block are probably damaged as well. Both the camshaft and bearings will have to be renewed. Renewal of the camshaft bearings requires special tools and techniques which place it beyond the scope of the home mechanic. The block will have to be removed from the vehicle and taken to an automotive machine shop for this procedure.

23 Measure the bearing journals with a micrometer to determine if they are excessively worn or out-of-round and compare to this Chapter's Specifications (see illustration 12.27 in Part A of this Chapter).

24 Check the camshaft lobes for heat discolouration, score marks, chipped areas, excessive pitting and uneven wear. Measure each lobe at the base circle (minimum dimension) and across the peak of the lobe. Subtract the two measurements to get the lobe lift. Compare your measurements to the figures listed in the Specifications in this Chapter. If the lobes are in good condition and if the lobe lift measurements are as specified, the camshaft can be reused.

REFITTING

25 Lubricate the camshaft bearing journals and cam lobes with clean oil or special camshaft assembly lube.

26 Slide the camshaft slowly and carefully into the engine. Support the cam near the block and be careful not to scrape or nick the bearings.

27 Refit the camshaft locator and check the endplay using a dial indicator mounted on the front of the block. Compare your reading to the figure listed in the Specifications in this Chapter. If the endplay is excessive, the camshaft or the locator will have to be renewed.

28 Refer to Section 10 and refit the timing chain and sprockets, with the timing marks aligned.

> ***Note:*** *If the engine has accumulated enough kilometres for the camshaft/lifters to have been renewed, this is the time to also renew the timing chain and sprocket set.*

29 Lubricate the lifters with clean engine assembly lube and refit them in the block. If the original lifters are being refitted, be sure to return them to their original locations.

30 The remaining refitting steps are the reverse of removal.

31 Before starting and running the engine, change the oil and fit a new oil filter (see Chapter 1).

32 Run the engine and check for leaks.

13 Oil pump - removal, inspection and refitting

REMOVAL

Refer to illustration 13.4

1 Raise the vehicle and support it securely on jackstands. Place a drain pan beneath the oil pump.

2 Remove the oil filter (see Chapter 1).

3 Disconnect the oil pressure harness wiring from the switch.

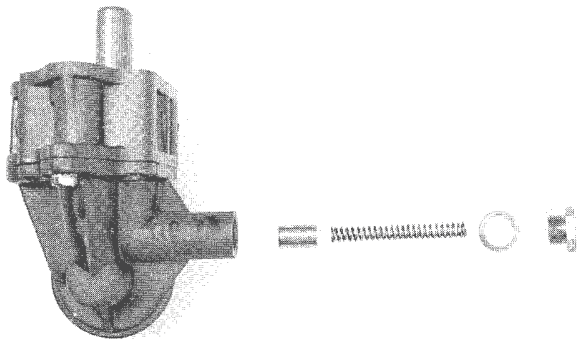
4 Remove the four bolts which secure the pump to the block (see illustration). Do not remove the two cover bolts at this time. Pull the oil pump from the block.

INSPECTION

Refer to illustrations 13.5, 13.7, 13.11a and 13.11b

5 Remove the two bolts which secure the cover to the pump (see illustration). Remove the cover and gasket.

6 Use a centre punch to mark the mating teeth for reassembly, then remove the gears.



13.7 The regulator valve must slide smoothly in the bore without being a loose fit. The length of the spring must be approximately 82.5 mm

7 Remove the plug over the regulator assembly and remove the gasket, spring and valve (see illustration).

8 Clean the parts with solvent and dry them with compressed air (if available).

***Warning:** Wear eye protection!*

9 Inspect all components for wear and score marks. Renew any worn out or damaged components.

10 Refit the gears in the housing, aligning the match marks previously made.

11 Check the protrusion of the gears from the body of the pump using a straight-edge and a feeler gauge. Compare your reading to that listed in the Specifications in this Chapter. Feeler gauges can be inserted under a straightedge (between the straightedge and the housing) held across the gears to determine the existing clearance (see illustration). Also make sure that the length of the drive gear (A) is between 68.96 and 69.22 mm (see illustration).

12 Check for pump cover warpage by laying a precision straight-edge across the cover and trying to slip a feeler gauge between the cover and straightedge.

13 Check the backlash of the gears and compare your reading to that listed in the Specifications in this Chapter.

14 Make certain that the regulator valve slides smoothly in its bore. Check that the spring is in good condition and that the free length of the spring is approximately 82.5 mm.

REFITTING

15 Refit the regulator valve, spring, gasket and plug. Tighten the plug to the torque listed in this Chapter's Specifications.

16 Oil the pump gears and make sure that they are refitted with their match marks aligned.

17 Fill a new oil filter with oil and fit it onto the housing (refer to Chapter 1). Fill the housing with engine oil.

***Caution:** It is important that the oil pump assembly is primed with oil prior to starting the engine. Failure to do so can result in a no oil pressure condition and possible engine damage.*

18 Refit the pump cover, using a new Holden gasket only - its thickness is critical for maintaining the correct clearances. Tighten the two bolts to the torque listed in this Chapter's Specifications.

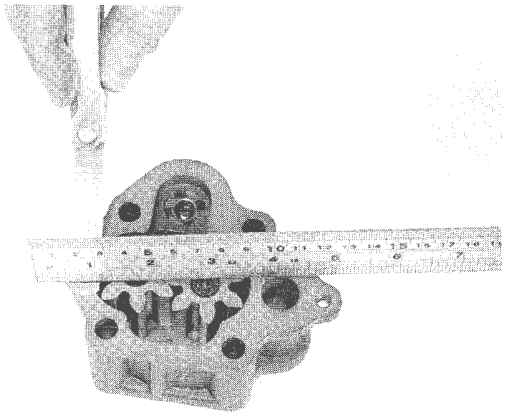
19 Refit the assembly onto the engine and tighten the mounting bolts to the torque listed in this Chapter's Specifications.

20 Remove the oil pressure switch and fully prime the pump with engine oil. Refit the switch.

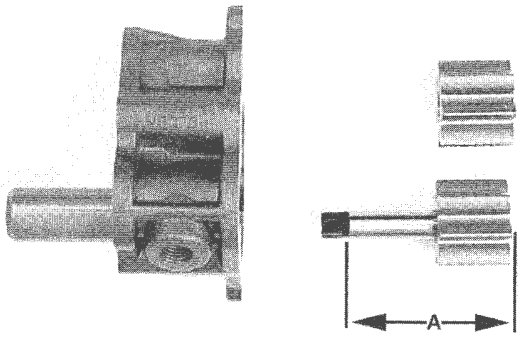
21 Start the engine and verify that correct oil pressure is produced quickly. If it is not, check your work and completely prime the pump with engine oil again.

14 Sump - removal and refitting

***Warning:** The front crossmember must be removed to provide sufficient clearance for sump removal. On refitting the crossmember must be centered exactly as originally refited or poor steering performance will result. Some special tools and techniques will be required to perform this procedure. The engine must be supported from above before removing the crossmember and remain supported the entire time the crossmember is removed. Do not attempt this procedure unless the necessary tools and equipment are available.*



13.11a Use a straight edge and a feeler gauge to make sure the gears protrude the specified distance from the housing - if they don't, renew them



13.11b Check the drive gear and shaft length (A) - it must be 68.96 to 69.22 mm. Make sure the driveshaft is securely mounted in the drive gear - renew them if they aren't

1 Disconnect the cable from the negative battery terminal.

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*

2 Raise the vehicle and support it securely on jackstands. Drain the engine oil and remove the oil filter (refer to Chapter 1 if necessary). Refit the drain plug into the sump and tighten it securely.

3 Remove the starter (refer to Chapter 5).

4 Apply alignment marks on the frame rails and front crossmember at each mounting bolt location. The crossmember must be centered in relation to the vehicle centreline when refitted, so take several measurements and apply several precise alignment marks to accomplish this. Remove the crossmember as follows:

a) Remove the front wheels.
b) Remove the brake caliper and suspend it from the spring. Remove the brake disc (see Chapter 9).
c) Detach the lower ball joint from the steering knuckle and the stabiliser bar from the strut (see Chapter 10).
d) Remove the steering gear mounting bolts and support the steering gear.
e) Using an engine hoist or 3-bar engine support fixture, raise the engine slightly and remove the through-bolts from the engine mounts.
f) Support the crossmember with a floor jack and remove the crossmember-to-frame rail bolts. Lower the crossmember and remove it from under the vehicle.

5 Remove the sump mounting bolts and carefully separate the sump from the block. Don't prise between the block and the sump or damage to the sealing surfaces may result and oil leaks may develop. Instead, tap the sump with a soft-face hammer to break the gasket seal. Twist the sump while lowering the rear of the sump.

6 Clean the sump with solvent and remove all old sealant and gasket material from the block and sump mating surfaces. Clean the mating surfaces with lacquer thinner or acetone and make sure the bolt holes in the block are clear. Check the sump flange for distortion, particularly around the bolt holes. If necessary, place the sump flange on a block of wood and use a hammer to flatten and restore the gasket surface.

7 Always use a new gasket whenever the sump is fitted. In addition, apply a bead of RTV silicone about 2 mm thick to the points where the sump contacts the front cover.

8 Place the sump in position on the block and refit the bolts.

9 After the bolts are refitted, tighten them to the torque listed in this Chapter's Specifications. Starting at the centre, follow a criss-cross pattern and work up to the final torque in three steps.

10 The remaining steps are the reverse of the removal procedure. Refit the crossmember, aligning the marks made during removal. Apply thread locking compound to the crossmember mounting bolt threads. Centre the crossmember and tighten the mounting bolts to 90 Nm. Tighten the lower balljoint bolts, the stabiliser bolts and the steering gear mounting bolts to the torque listed in Chapter 10 Specifications

11 Refill the engine with oil. Fill the oil filter with engine and refit it. Run the engine until normal operating temperature is reached and check for leaks. Have the front end alignment checked by a dealer service department or front end alignment shop.

15 Oil pump pick-up tube and screen assembly - removal and refitting

1 Remove the sump (see Section 14).

2 Unbolt the oil pump pick-up tube and screen assembly and detach it from the engine.

3 Clean the screen and tube assembly with solvent and dry it with compressed air, if available.

Warning: *Wear eye protection.*

4 If the oil screen is damaged or has metal chips in it, renew it. An abundance of metal chips indicates a major engine problem which must be corrected.

5 Clean the mounting holes in the block with acetone and compressed air. Apply Loctite 242 to the threads of the bolts. Make sure the mating surfaces of the pipe flange and the engine block are clean and free of nicks and refit the screen assembly with a new gasket or O-ring.

Caution: *It is critical that no air leaks are present in the pick-up tube assembly at any point.*

6 Refit the sump (see Section 15).

7 Be sure to refill the engine with oil before starting it.

16 Flywheel/driveplate - removal and refitting

1 Disconnect the negative battery cable.

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*

2 Refer to Chapter 7 and remove the transmission.

3 Remove the clutch from manual transmission vehicles. Remove the torque converter from vehicles with automatic transmissions.

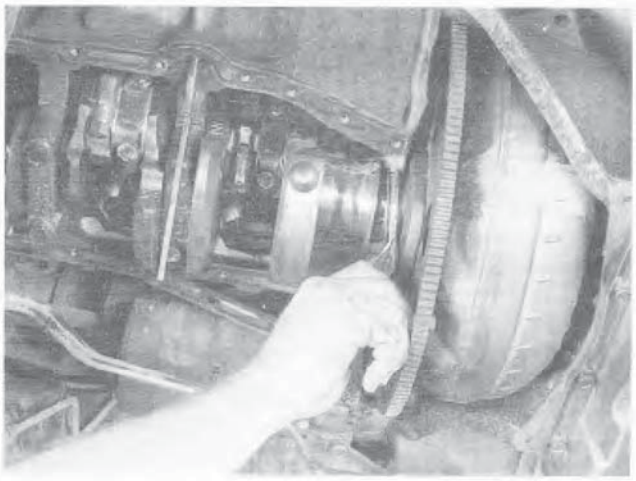
4 Use a flywheel holder or a large screwdriver to lock the flywheel as you remove the bolts.

5 Remove the flywheel/driveplate.

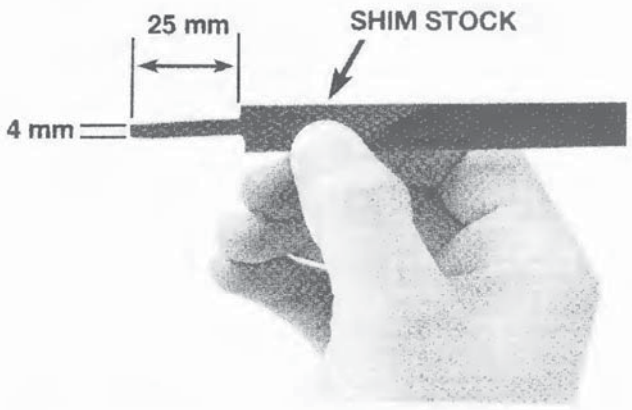
Caution: *The manual transmission flywheel is heavy. Use care and support it as you remove the last bolt. Use gloves or a rag to hold it.*

6 Clean the flywheel thoroughly and inspect it for cracks, grooves, burned areas and score marks. Check for broken or worn ring gear teeth. Refer to Chapter 8 for more information on the dual mass flywheel.

7 Check the runout of the automatic transmission driveplate using a dial indicator. A slight amount of runout can be



17.5 Once the upper half of the seal has been adequately driven around the crankshaft, pull it out with a pair of pliers



17.9 Fabricate this tool for the rear main oil seal

repaired by careful tapping of the high spots with a rubber mallet.

8 Apply Loctite 242 to the threads of the bolts. Torque them to the Specification in this Chapter.

9 Refitting is the reverse of removal.

17 Rear main oil seal - renewal

Refer to illustrations 17.5, 17.9, 17.13a, 17.13b and 17.14

1 Always replace both halves of the rear main oil seal as a set. While the replacement of this seal is much easier with the engine removed from the vehicle and the crankshaft removed from the engine, the job may be accomplished with engine in place.

2 Remove the sump as described previously in this Chapter.

3 Remove the rear main bearing cap from the engine.

4 Prise the lower half of the oil seal from the bearing cap.

5 To remove the upper half of the seal, use a small hammer and a brass pin punch to roll the seal around the crankshaft journal. Tap one end of the seal with the hammer and punch (be careful not to strike the crankshaft) until the other end of the seal protrudes enough to pull the seal out with a pair of pliers (see illustration).

6 Clean all seal and foreign material from the bearing cap and block. Do not use an abrasive cleaner for this.

7 Inspect components for nicks, scratches or burrs at all sealing surfaces.

8 Coat the seal lips of the new seal with light engine oil. Do not get oil on the seal mating ends.

9 Included in the purchase of the rear main oil seal should be a small plastic tool. If not included, make your own by cutting an old feeler gauge blade or shim stock (see illustration).

10 Position the narrow end of this tool between the crankshaft and the seal seat. The idea is to protect the new seal from being damaged by the sharp edge of the seal seat.

11 Raise the new upper half of the seal into position with the seal lips facing towards the front of the engine. Push the seal onto its seat, using the tool as a protector against the seal contacting the sharp edge.

12 Roll the seal around the crankshaft, all the time using the tool as a "shoehorn" for protection. When both ends of the seal protruding from the engine block are equal length, remove the tool. Carefully cut both ends of the seal flush with the engine block.

13 Apply a small bead of retaining compound (such as Loctite 609) in the seal groove then refit the lower half of the oil seal in the bearing cap. Use a large diameter section of pipe or socket to press the seal into the groove. Carefully cut both ends of the seal flush with the bearing cap (see illustrations).

14 Apply anaerobic sealant on the bearing cap areas immediately adjacent to the seal ends (see illustration).

15 Refit the bearing cap (with seal) and tighten the attaching bolts to approximately 3 to 5 Nm. Now tap the end of the crankshaft first rearward, then forward with a soft faced hammer to line up the thrust bearing surfaces. Tighten the bearing cap bolts to the torque listed in the Chapter 2E Specifications.

18 Engine mounts - check and renewal

1 Engine mounts seldom require attention, but broken or deteriorated mounts should be renewed immediately or the added strain placed on the driveline components may cause damage or wear.

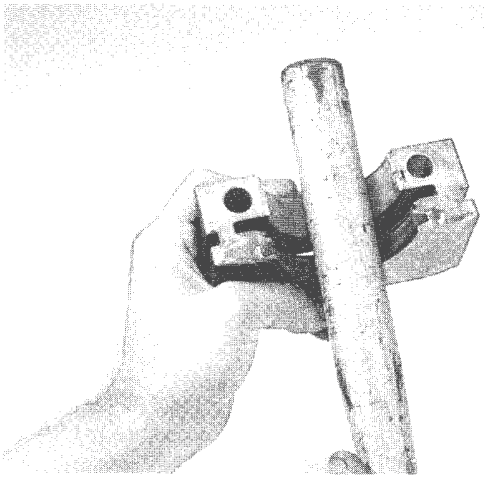
CHECK

2 During the check, the engine must be raised slightly to remove the weight from the mounts.

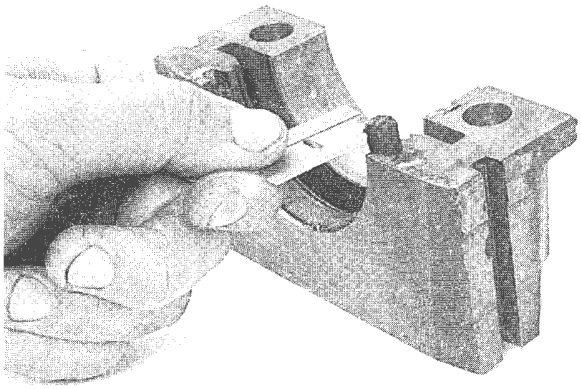
3 Raise the vehicle and support it securely on jackstands. Place a floor jack with a wood block on the head of the jack under the sump and raise the engine slightly.

Caution: *Don't apply too much force on the jack - the engine sump could be damaged.*

4 Check the mounts to see if the rubber is cracked, hardened or separated from the metal plates. Sometimes the rubber will split right down the centre.



17.13a Press the new seal into the groove in the main bearing cap with a hammer handle or large-diameter socket



17.13b Carefully cut the ends of the seal flush with the bearing cap

5 Check for relative movement between the mount plates and the engine or frame (use a large screwdriver or lever to attempt to move the mounts). If movement is noted, lower the engine and tighten the mount fasteners.

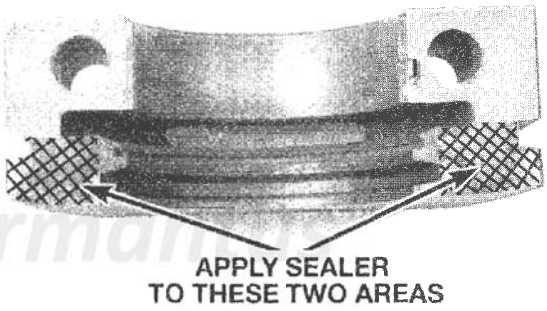
6 Rubber preservative may be applied to the mounts to slow deterioration.

RENEWAL

7 Disconnect the cable from the negative terminal of the battery, then raise the vehicle and support it securely on jackstands (if not already done).

8 Raise the engine slightly with an engine hoist, or by using the method described in Step 3. Remove the through-bolts from the engine bracket and detach the mount from the frame.

9 Refitting is the reverse of removal.



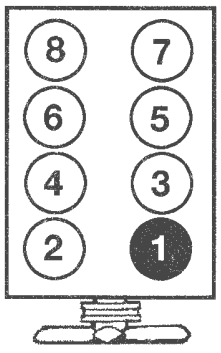
17.14 Apply anaerobic sealant to the indicated areas of the main bearing cap

Notes

Chapter 2
Engine

Part D. 5.7 litre Gen III and 6.0 litre Gen IV V8 engines

Contents



Cylinder numbering

Specifications

General

Displacement	
5.7 litre	5,667 cc
6.0 litre	5,967 cc
Bore and stroke	
5.7 litre	99.0 x 92.0 mm
6.0 litre	101 x 92 mm
Cylinder numbers (front-to-rear)	
Left side	1-3-5-7
Right (drivers) side	2-4-6-8
Firing order	1-8-7-2-6-5-4-3
Cylinder compression pressure	690 kPa
Maximum variations between cylinders	25-percent from the highest reading

Camshaft

Journal diameter	54.99 to 55.04 mm
Camshaft endplay	0.025 to 0.305 mm

Lobe lift

Lobe lift	7.43 mm
Lobe height	46.67 mm (minimum)

Torque specifications*

Nm (unless otherwise indicated)

Camshaft sprocket bolts	
5.7 litre	35
6.0 litre	
Step one	75
Step two	Turn an additional 50 degrees
Camshaft retainer bolts	25
Crankshaft balancer bolt	
Step one (use NEW bolt)	50
Step two (use NEW bolt)	Turn an additional 140 degrees
Cylinder head bolts - 5.7 litre (VT to VY models)	
Step one	
All M11 (use NEW bolts) and M8 bolts	30
Step two	
All M11 bolts	Turn an additional 90 degrees
Step three	
M11 bolts (1 through 8)	Turn an additional 90 degrees
M11 bolts (9 and 10)	Turn an additional 50 degrees

***Note:** Refer to Part E for additional specifications.*

Torque specifications* (cont'd)	Nm (unless otherwise indicated)
Cylinder head bolts - VZ 5.7 litre and 6.0 litre	
Step one	
All M11 (use NEW bolts) and M8 bolts	30
Step two	
All M11 bolts	Turn an additional 90 degrees
Step three	
All M11 bolts	Turn an additional 90 degrees
Engine mount retaining bolts	40 to 60
Engine mount nuts	80
Exhaust manifold bolts	
Step one	15
Step two	25
Exhaust manifold heat shield bolt	9
Exhaust pipe flange nuts	20 to 35
Front timing chain cover bolts	25
Flywheel/driveplate bolts	
Step one	20
Step two	50
Step three	100
Inlet manifold bolts	
Step one	5
Step two	10
Sump baffle bolts	12
Sump drain plug	25
Sump rear access plugs	12
Sump bolts	25
Sump to rear cover bolts	12
Oil pump cover bolts	12
Oil pump mounting bolts	25
Rocker arm bolts	30
Valve cover bolts	12
Valley cover bolts	25
Vapour vent pipe bolts	12

***Note:** Refer to Part E for additional specifications.*

1 General information

***Warning:** The models covered by this manual are equipped with airbags. Always disable the airbag system before working in the vicinity of the impact sensors, steering column or instrument panel to avoid the possibility of accidental deployment of the airbag(s), which could cause personal injury (see Chapter 12).*

***Caution:** On models equipped with a Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery.*

This Part of Chapter 2 is devoted to in-vehicle repair procedures for the Generation III 5.7L and Generation IV 6.0 litre V8 engines. The main difference between the two types of engines covered is bore size. The only other major difference is the valve lifter setup which, on the 6.0L engine, has the hardware to allow the computer to isolate cylinders during cruise, allowing the vehicle to run on four cylinders. This system is not activated in Australia. All information concerning engine removal and refitting and engine block and cylinder head overhaul on either of these V8 engines can be found in Part E of this Chapter.

Since the repair procedures included in this Part are based on the assumption the engine is still in the vehicle, if they are being used during a complete engine overhaul (with the engine already out of the vehicle and on a stand) many of the Steps included here will not apply.

The Specifications included in this Part of Chapter 2 apply only to the procedures found here. The specifications necessary for rebuilding the block and cylinder heads are included in Part E.

The engine utilizes an aluminium block with cast-iron sleeves. The eight cylinders are arranged in a "V" shape at a 90-degree angle between the two banks. The cylinder heads utilize an overhead valve arrangement. The engine uses aluminium cylinder heads with powdered metal guides and valve seats. Hydraulic roller lifters actuate the valves through tubular pushrods and rocker arms. The oil pump is mounted at the front of the engine behind the timing chain cover and is driven by the crankshaft.

2 Repair operations possible with the engine in the vehicle

Many major repair operations can be accomplished without removing the engine from the vehicle.

Clean the engine compartment and the exterior of the engine with some type of pressure washer before any work is done. A clean engine will make the job easier and will help keep dirt out of the internal areas of the engine.

Depending on the components involved, it may be a good idea to remove the bonnet to improve access to the engine as repairs are performed (refer to Chapter 11 if necessary).

If oil or coolant leaks develop, indicating a need for gasket or seal renewal, the repairs can generally be made with the engine in the vehicle. The sump gasket, the cylinder head gaskets, inlet and exhaust manifold gaskets, timing chain cover gaskets and the crankshaft oil seals are all accessible with the engine in place.

Exterior engine components, such as the water pump, the starter motor, the alternator, the power steering pump and the fuel injection components, as well as the inlet and exhaust manifolds, can be removed for repair with the engine in place.

Since the cylinder heads can be removed without removing the engine, valve component servicing can also be accomplished with the engine in the vehicle.

Renewal of, repairs to or inspection of the timing chain and sprockets and the oil pump are all possible with the engine in place.

In extreme cases caused by a lack of necessary equipment, repair or renewal of piston rings, pistons, connecting rods and rod bearings is possible with the engine in the vehicle. However, this practice is not recommended because of the cleaning and preparation work that must be done to the components involved.

3 Top Dead Centre (TDC) for number one piston - locating

Refer to illustration 3.6

1 Top Dead Centre (TDC) is the highest point in the cylinder that each piston reaches as it travels up the cylinder bore.

Each piston reaches TDC on the compression stroke and again on the exhaust stroke, but TDC generally refers to piston position on the compression stroke.

2 Positioning the piston(s) at TDC is an essential part of many procedures such as distributor and timing chain/sprocket removal.

3 Before beginning this procedure, be sure to place the transmission in Neutral and apply the parking brake or block the rear wheels. Also, disable the ignition system by disconnecting the primary electrical connectors at the ignition coil packs, then remove the spark plugs (see Chapter 1).

4 In order to bring any piston to TDC, the crankshaft must be turned using one of the methods outlined below. When looking at the front of the engine, normal crankshaft rotation is clockwise.

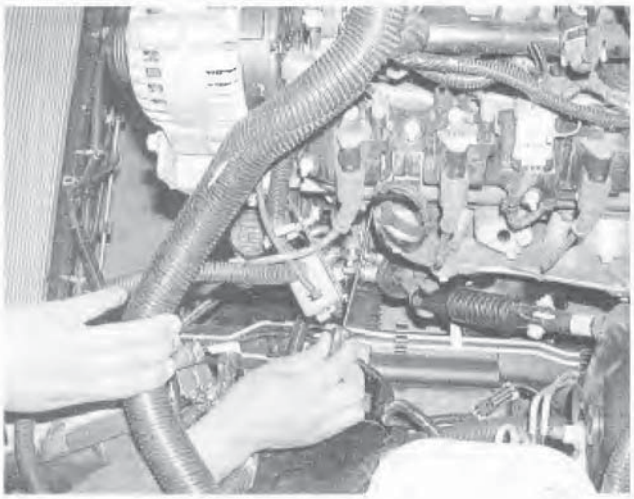
a) The preferred method is to turn the crankshaft with a socket and ratchet attached to the bolt threaded into the front of the crankshaft. Apply pressure on the bolt in a clockwise direction only. Never turn the bolt anti-clockwise.

b) A remote starter switch, which may save some time, can also be used. Follow the instructions included with the switch. Once the piston is close to TDC, use a socket and ratchet as described in the previous paragraph.

c) If an assistant is available to turn the ignition switch to the Start position in short bursts, you can get the piston close to TDC without a remote starter switch. Make sure your assistant is out of the vehicle, away from the ignition switch, then use a socket and ratchet as described in Paragraph (a) to complete the procedure.

5 Place your finger partially over the number one spark plug hole and rotate the crankshaft using one of the methods described above until air pressure is felt at the spark plug hole. Air pressure at the spark plug hole indicates that the cylinder has started the compression stroke. Once the compression stroke has begun, TDC for the number one cylinder is obtained when the piston reaches the top of the cylinder on the compression stroke.

6 To bring the piston to the top of the cylinder, insert a long screwdriver into the number one spark plug hole until it touches the top of the piston.



3.6 A long screwdriver inserted in the number one spark plug hole can be used to determine the highest point reached by that piston - make sure to wrap the tip of the screwdriver with tape to avoid scratching the top of the piston or the cylinder walls

***Note:** Make sure to wrap the tip of the screwdriver with tape to avoid scratching the top of the piston and the cylinder walls.*

Use the screwdriver (as a feeler gauge) to tell where the top of the piston is located in the cylinder while slowly rotating the crankshaft (see illustration). As the piston rises the screwdriver will be pushed out. The point at which the screwdriver stops moving outward is TDC.

***Note:** Always hold the screwdriver upright while the engine is being rotated so that the screwdriver will not get wedged as the piston travels upward.*

7 If you go past TDC, rotate the crankshaft anti-clockwise until the piston is approximately 20 mm below TDC, then slowly rotate the crankshaft clockwise again until TDC is reached.

8 After the number one piston has been positioned at TDC on the compression stroke, TDC for any of the remaining pistons can be located by repeating the procedure described above and following the firing order.

4 Valve covers - removal and refitting

REMOVAL

Refer to illustrations 4.2, 4.4, 4.7 and 4.9

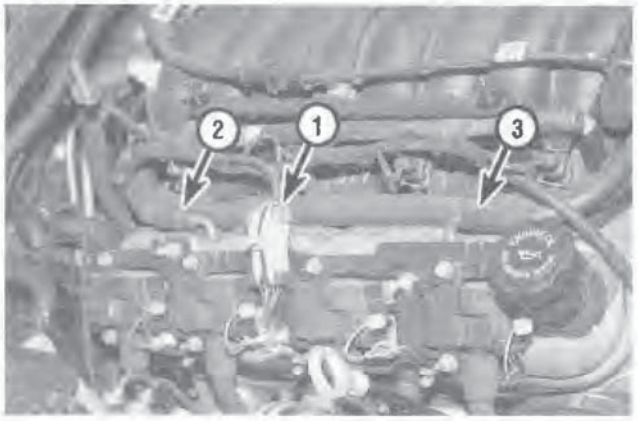
1 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the engine dress cover mounting nuts and remove the cover (see illustration).

3 Remove the air cleaner and resonator assembly to allow access to the front of the engine (see Chapter 4).

4.2 Remove the engine cover retaining nuts (arrows) and remove the cover



4.4 Disconnect the coil main wiring harness connector (1), the PCV hose (2) and the fresh air hose (3) from the valve cover - right side shown

Right side

4 Unclip the wiring harness from the ignition coil bracket and lay it aside. Remove the fresh air hose and PCV hose from the valve cover (see illustration).

5 Remove the ignition coils from the valve cover (see Chapter 5). Be sure each plug wire is labeled before removal to ensure correct refitting.

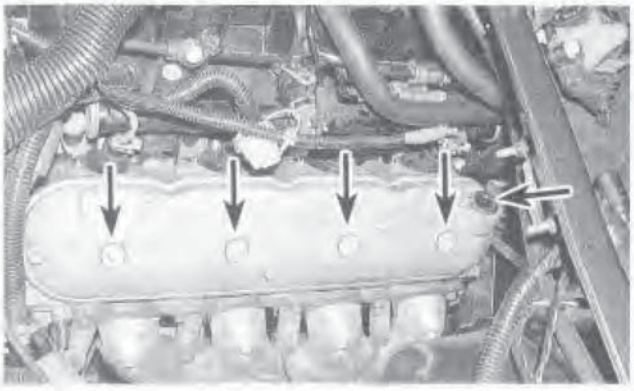
6 Remove the valve cover bolts, then detach the cover from the cylinder head (see illustration 4.9).

> ***Note:*** *If the cover is stuck to the cylinder head, bump one end with a block of wood and a hammer to jar it loose. If that doesn't work, try to slip a flexible putty knife between the cylinder head and cover to break the gasket seal. Don't prise at the cover-to-head joint or damage to the sealing surfaces may occur (leading to oil leaks in the future).*

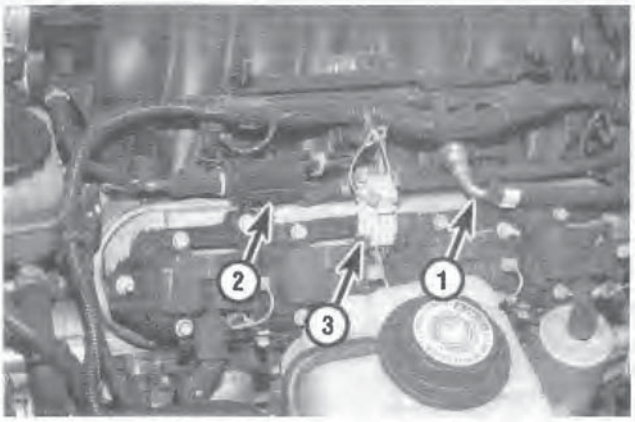
Left side

7 Relieve the fuel system pressure and detach the fuel feed and return lines from the fuel rail and the vapour purge valve (see illustration) (see Chapter 4). Unclip the wiring harness from the ignition coil bracket and lay it aside.

8 Remove the ignition coils from the valve cover (see Chapter 5). Be sure each plug wire is labeled before removal to ensure correct refitting.



4.9 Valve cover mounting bolts (arrows) - arrow to the far right indicates location of the PCV valve (left valve cover shown)



4.7 Using the quick release tool remove the fuel line (1), then disconnect the EVAP purge valve and line (2) and coil main wiring harness (3) - left side shown

9 Remove the valve cover bolts (see illustration), then detach the cover from the cylinder head.

> ***Note:*** *If the cover is stuck to the cylinder head, bump one end with a block of wood and a hammer to jar it loose. If that doesn't work, try to slip a flexible putty knife between the cylinder head and cover to break the gasket seal. Don't prise at the cover-to-head joint or damage to the sealing surfaces may occur (leading to oil leaks in the future).*

REFITTING

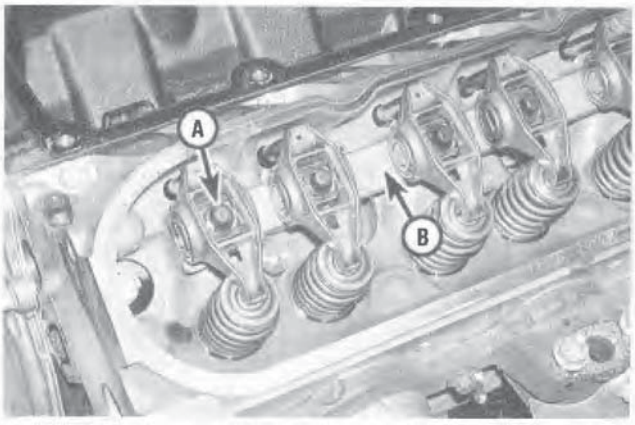
Refer to illustration 4.12

10 The mating surfaces of each cylinder head and valve cover must be perfectly clean when the covers are refitted. Use a gasket scraper to remove all traces of sealant and old gasket material, then clean the mating surfaces with lacquer thinner or acetone. If there's sealant or oil on the mating surfaces when the cover is refitted, oil leaks may develop.

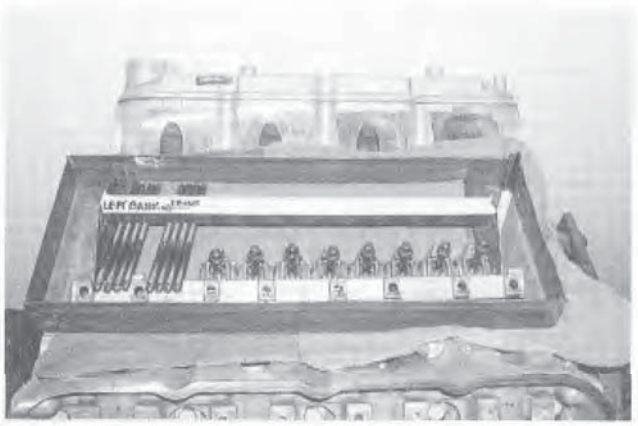
11 Clean the mounting bolt threads with a die to remove any corrosion and restore damaged threads. Make sure the threaded holes in the cylinder head are clean - run a tap into them to remove corrosion and restore damaged threads.

12 The gaskets should be mated to the covers before the covers are refitted. Position the gasket inside the cover lip (see illustration). If the gasket will not stay in place in the cover lip,

4.12 Position the new gasket in the valve cover lip



5.2 Remove the mounting bolts (A) and rocker arms, then remove the pivot support pedestal (B)



5.3 Store the pushrods and rocker arms in order to ensure they are refitted in their original locations - note the arrow indicating the front of the engine

apply a thin coat of RTV sealant to the cover flange, and allow the sealant to set up so the gasket adheres to the cover.

13 Inspect the valve cover bolt grommets for damage. If the grommets aren't damaged they can be reused. Carefully position the valve cover(s) on the cylinder head and refit the bolts and grommets.

14 Tighten the bolts in three or four steps to the torque listed in this Chapter's Specifications.

15 The remaining refitting steps are the reverse of removal.

16 Start the engine and check carefully for oil leaks as the engine warms up.

5 Rocker arms and pushrods - removal, inspection and refitting

REMOVAL

Refer to illustrations 5.2 and 5.3

1 Refer to Section 4 and detach the valve covers from the cylinder heads.

5.4 Rocker arm wear points

A Pushrod socket
B Pivot bearings
C Valve stem contact point

2 Loosen the rocker arm pivot bolts one at a time and detach the rocker arms and bolts, then detach the pivot support pedestal (see illustration). Keep track of the rocker arm positions, since they must be returned to the same locations. Store each set of rocker components separately in a marked plastic bag to ensure that they're refitted in their original locations.

3 Remove the pushrods and store them separately to make sure they don't get mixed up during refitting (see illustration).

INSPECTION

Refer to illustration 5.4

4 Check each rocker arm for wear, cracks and other damage, especially where the pushrods and valve stems contact the rocker arm (see illustration).

5 Check the pivot bearings for binding and roughness. If the bearings are worn or damaged, renewal of the entire rocker arm will be necessary.

> ***Note:*** *Keep in mind that there is no valve adjustment on these engines, so excessive wear or damage in the valve train can easily result in excessive valve clearance, which in turn will cause valve noise when the engine is running.*

Also check the rocker arm pivot support pedestal for cracks and other obvious damage.

6 Make sure the hole at the pushrod end of each rocker arm is open.

7 Inspect the pushrods for cracks and excessive wear at the ends, also check that the oil hole running through each pushrod is not clogged. Roll each pushrod across a piece of plate glass to see if it's bent (if it wobbles, it's bent).

REFITTING

Refer to illustration 5.9

8 Lubricate the lower end of each pushrod with clean engine oil or engine assembly lube and refit them in their original locations. Make sure each pushrod seats completely in the lifter socket.

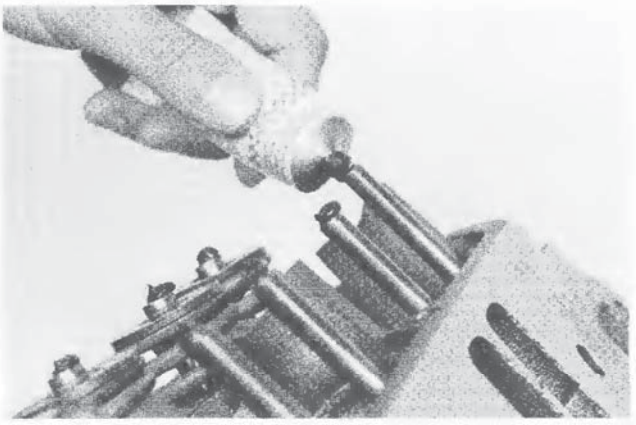
9 Apply engine assembly lube to the ends of the valve stems and to the upper ends of the pushrods to prevent damage to

the mating surfaces on initial start-up (see illustration). Also apply clean engine oil to the pivot shaft and bearing of each rocker arm and refit the rocker arms loosely in their original locations. DO NOT tighten the bolts at this time!

10 Rotate the crankshaft until the number one piston is at TDC (see Section 3). With the number one piston is at TDC, tighten the inlet valve rocker arms for the Number 1, 3, 4 and 5 cylinders and the exhaust rocker arms for the Number 1, 2, 7 and 8 cylinders. Tighten each of the specified rocker arm bolts to the torque listed in this Chapter's Specifications.

11 Rotate the crankshaft 360 degrees. Tighten the inlet valve rocker arms for the Number 2, 6, 7 and 8 cylinders and the exhaust rocker arms for the Number 3, 4, 5 and 6 cylinders. Tighten each of the rocker arm bolts to the torque listed in this Chapter's Specifications.

12 Refer to Section 4 and refit the valve covers. Start the engine, listen for unusual valve train noises and check for oil leaks at the valve cover gaskets.



5.9 Lubricate the pushrod ends and the valve stems with engine assembly lube before refitting the rocker arms

6 Valve springs, retainers and seals - renewal

Refer to illustrations 6.5, 6.8, 6.10, 6.15a, 6.15b and 6.19

Note: *Broken valve springs and defective valve stem seals can be renewed without removing the cylinder head. Two special tools and a compressed air source are normally required to perform this operation, so read through this Section carefully and rent or buy the tools before beginning the job.*

1 Remove the spark plugs (see Chapter 1).

2 Remove the valve covers (see Section 4).

3 Rotate the crankshaft until the number one piston is at top dead centre on the compression stroke (see Section 3).

4 Remove the rocker arms for the number 1 piston.

5 Thread an adapter into the spark plug hole and connect an air hose from a compressed air source to it (see illustration). Most auto parts stores can supply the air hose adapter.

Note: *Many cylinder compression gauges utilize a screw-in fitting that may work with your air hose quick-disconnect fitting. If a cylinder compression gauge fitting is used it will be necessary to remove the schrader valve from the end of the fitting before using it in this procedure.*

6.5 This is what the air hose adapter that fits into the spark plug hole looks like - they're commonly available from auto parts stores

6 Apply compressed air to the cylinder. The valves should be held in place by the air pressure.

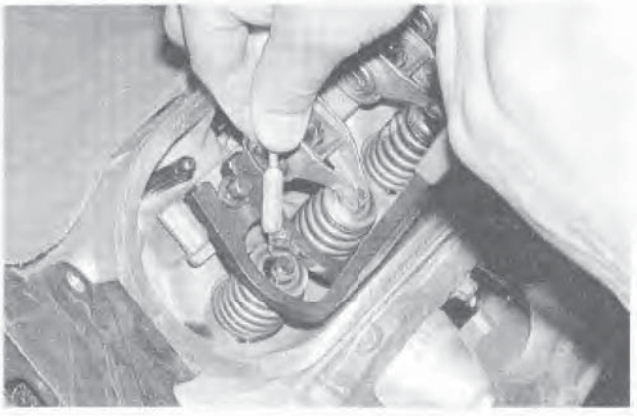
Warning: *If the cylinder isn't exactly at TDC, air pressure may force the piston down, causing the engine to quickly rotate. DO NOT leave a wrench on the crankshaft balancer bolt or you may be injured by the tool.*

7 Stuff shop rags into the cylinder head holes around the valves to prevent parts and tools from falling into the engine.

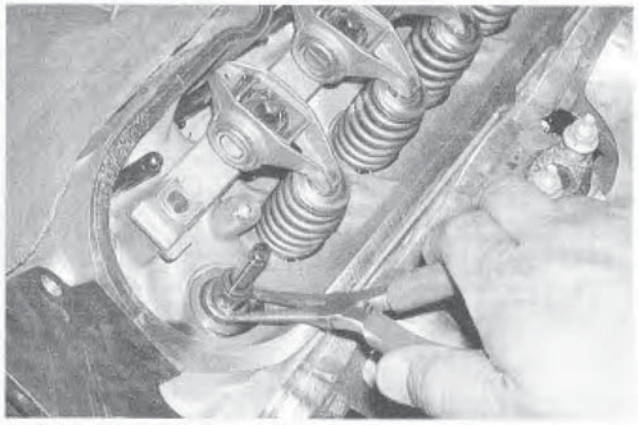
8 Using a socket and a hammer gently tap on the top of each valve spring retainer several times (this will break the seal between the valve collet and the spring retainer and allow the collet to separate from the valve spring retainer as the valve spring is compressed), then use a valve-spring compressor to compress the spring. Remove the collets with small needle-nose pliers or a magnet (see illustration).

Note: *Several different types of tools are available for compressing the valve springs with the head in place. One type grips the lower spring coils and presses on the retainer as the knob is turned, while the lever-type shown here utilizes the rocker arm bolt for leverage. Both types work very well, although the lever type is usually less expensive.*

9 Remove the valve spring and retainer.



6.8 Once the spring is depressed, the collets can be removed with a small magnet or needle-nose pliers (a magnet is preferred to prevent dropping the collets)



6.10 Use a pair of needle-nose pliers to remove the valve seals

6.18 Apply small dab of grease to each collet as shown here before refitting - it'll hold them in place on the valve stem as the spring is released

Note: If air pressure fails to retain the valve in the closed position during this operation, the valve face or seat may be damaged. If so, the cylinder head will have to be removed for repair.

10 Remove the old valve stem seals, noting differences between the inlet and exhaust seals (see illustration).

11 Wrap a rubber band or tape around the top of the valve stem so the valve won't fall into the combustion chamber, then release the air pressure.

12 Inspect the valve stem for damage. Rotate the valve in the guide and check the end for eccentric movement, which would indicate that the valve is bent.

13 Move the valve up-and-down in the guide and make sure it does not bind. If the valve stem binds, either the valve is bent or the guide is damaged. In either case, the head will have to be removed for repair.

14 Reapply air pressure to the cylinder to retain the valve in the closed position, then remove the tape or rubber band from the valve stem.

15 Fit new valved stem seals, carefully pressing them over the ends of the inlet andexhaust valve guides.

16 Refit the spring and retainer in position over the valve.

17 Compress the valve spring assembly only enough to refit the collets in the valve stem.

18 Position the collets in the valve stem groove. Apply a small dab of grease to the inside of each collet to hold it in place if necessary (see illustration). Remove the pressure from the spring tool and make sure the collets are seated.

19 Disconnect the air hose and remove the adapter from the spark plug hole.

20 Repeat the above procedure on the remaining cylinders, following the firing order sequence (see this Chapter's Specifications). Bring each piston to top dead centre on the compression stroke before applying air pressure (see Section 3).

21 Refit the rocker arm assemblies and the valve covers (see Sections 4 and 5).

22 Start the engine, then check for oil leaks and unusual sounds coming from the valve cover area. Allow the engine to idle for at least five minutes before revving the engine.

7 Inlet manifold - removal and refitting

Warning: Wait until the engine is completely cool before starting this procedure.

REMOVAL

Refer to illustration 7.7

1 Disconnect the earth (-) lead from the battery.

Caution: On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).

2 Remove the engine dress cover (see illustration 4.2). Clamp off the coolant hoses leading to the throttle body.

3 Remove the air cleaner and the air inlet assembly, then relieve the fuel system pressure (see Chapter 4).

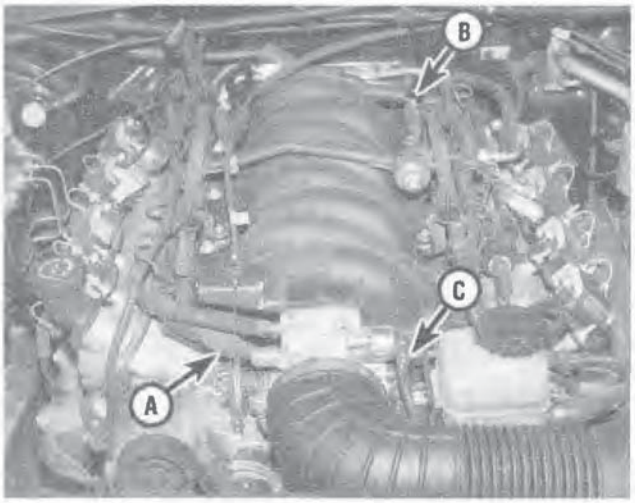
4 Disconnect the accelerator linkage (see Chapter 4) and, if equipped, the cruise control linkage.

5 Disconnect the electrical connectors from the fuel injectors, EVAP solenoid, the MAP sensor and from the sensors on the throttle body. Label each connector clearly to aid in the reassembly process. Also disconnect the knock sensors electrical connectors and detach the earth straps at the rear of the left cylinder head. Detach any remaining wiring harness brackets from the top of the inlet manifold and lay the harness aside.

6 Remove the fuel rails and injectors as an assembly (see Chapter 4). The two fuel rails can be pulled straight up with the injectors still attached, but it will take some force to dislodge the injectors from the inlet manifold.

Note: This Step is not absolutely necessary but it will help prevent subsequent damage to the fuel injectors as the inlet manifold is removed.

7 Disconnect the coolant hoses from the throttle body. Also disconnect any vacuum hoses attached to the inlet manifold or throttle body such as the power brake booster, the PCV and the EVAP purge control valve (see illustration on next page).



7.7 Detach the PCV hose, fresh air hose (A), the power brake booster vacuum hose (B) from the rear of the inlet and the TPS connector (C) from the throttle body

8 Disconnect any remaining electrical connectors or vacuum hoses connected to the inlet manifold or throttle body.

9 Loosen the inlet manifold mounting bolts in 1/4-turn increments in the reverse order of the tightening sequence until they can be removed by hand (see illustration 7.15). The manifold will probably be stuck to the cylinder heads and force may be required to break the gasket seal. A prise bar can be positioned between the front of the manifold and the valley tray to break the bond made by the gasket.

Caution: *Do not prise between the manifold and the heads or damage to the gasket sealing surfaces may result and vacuum leaks could develop. Also, don't use too much force - the manifold is made of a plastic composite and could crack.*

10 Remove the inlet manifold. As the manifold is lifted from the engine, be sure to check for and disconnect anything still attached to the manifold.

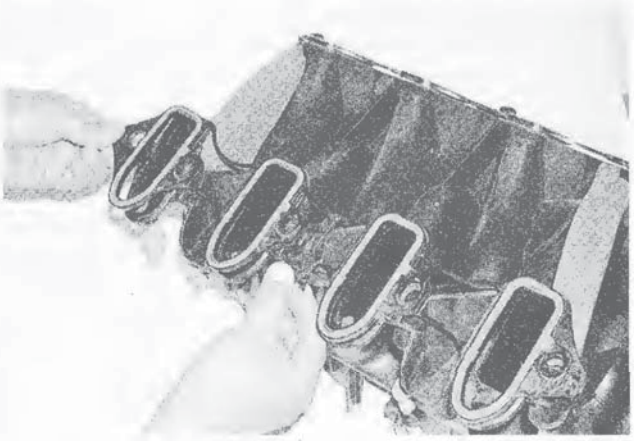
REFITTING

Refer to illustrations 7.13 and 7.15

Note: *The mating surfaces of the cylinder heads, block and manifold must be perfectly clean when the manifold is refitted.*

11 Carefully remove all traces of old gasket material. Note that the inlet manifold is made of a composite material and the cylinder heads are made of aluminium, therefore aggressive scraping is not suggested and will damage the sealing surfaces. After the gasket surfaces are cleaned and free of any gasket material wipe the mating surfaces with a cloth saturated with safety solvent. If there is old sealant or oil on the mating surfaces when the manifold is refitted, oil or vacuum leaks may develop. Use a vacuum cleaner to remove any gasket material that falls into the inlet ports in the heads.

12 Use a tap of the correct size to chase the threads in the bolt holes, then use compressed air (if available) to remove the debris from the holes.



7.13 Align the tabs on the inlet gaskets with the tabs on the manifold and snap the gasket into place

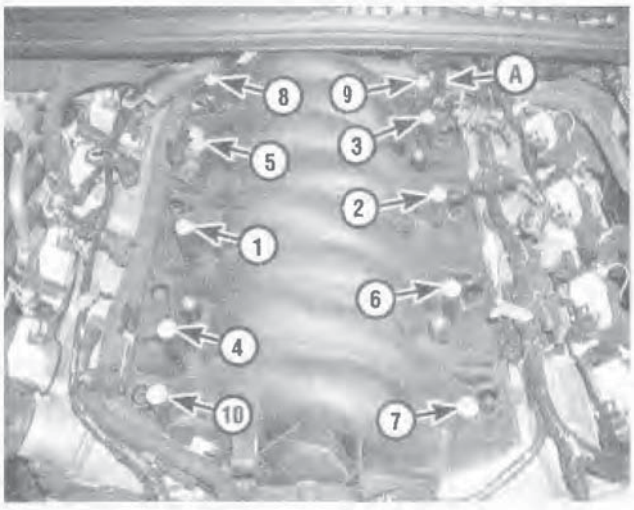
Warning: *Wear safety glasses or a face shield to protect your eyes when using compressed air.*

13 Position the new gaskets on the inlet manifold (see illustration). Note that the gaskets are equipped with refitting tabs that must snap into place on the inlet manifold. The words "Manifold Side" may appear on the gasket. If so, this will ensure proper refitting. Make sure the gaskets snap into place and all inlet port openings align.

14 Carefully set the manifold in place.

15 Apply medium-strength threadlocking compound to the threads of the bolts. Refit the bolts and tighten them following the recommended sequence (see illustration) to the torque listed in this Chapter's Specifications. Do not overtighten the bolts or gasket leaks may develop.

16 The remaining refitting steps are the reverse of removal. Check the coolant level, adding as necessary (see Chapter 1). Start the engine and check carefully for vacuum leaks at the inlet manifold joints.



7.15 Inlet manifold bolt tightening sequence
A Fuel stop bracket

8 Exhaust manifolds - removal and refitting

REMOVAL

Refer to illustrations 8.4, 8.8 and 8.9

Warning: *Use caution when working around the exhaust manifolds - the sheetmetal heat shields can be sharp on the edges. Also, the engine should be cold when this procedure is followed.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Raise the vehicle and support it securely on jackstands.

3 Working under the vehicle, apply penetrating oil to the exhaust pipe-to-manifold studs and nuts (they're usually rusty). Disconnect the electrical connector for oxygen sensor.

4 Remove the nuts retaining the exhaust pipe(s) to the manifold(s) (see illustration).

5 Detach the spark plug wires and remove the spark plugs from the side being worked on (see Chapter 1). If both manifolds are being removed, detach all the spark plug wires and remove all the spark plugs.

6 Remove the secondary air injection pipe (if equipped) from the exhaust manifold being removed (see Chapter 6).

7 Remove the valve cover from the side being worked on (see Section 4). If both manifolds are being removed, detach the both valve covers.

Right side manifold

8 Remove the oil dipstick, unbolt the dipstick tube bracket and move the dipstick tube (see illustration).

9 Remove the mounting bolts and separate the exhaust manifold from the cylinder head (see illustration). Remove the heat shields from the manifold after the manifold has been removed.

Left side manifold

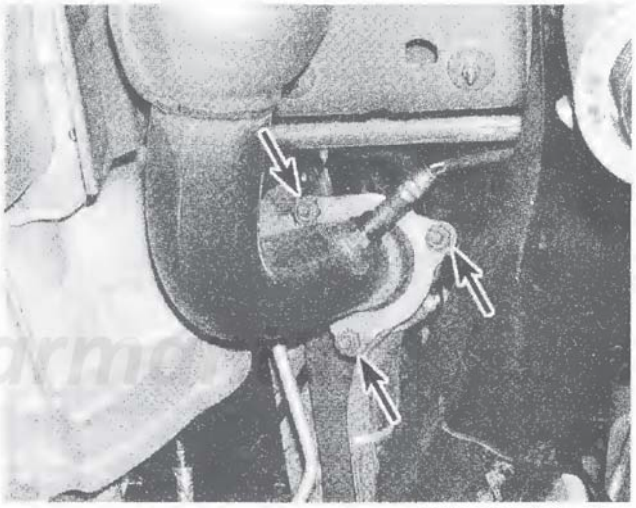
10 Disconnect the electrical connector from the Engine Coolant Temperature (ECT) sensor (see Chapter 6).

11 Remove the mounting bolts and separate the exhaust manifold from the cylinder head. Remove the heat shields from the manifold after the manifold has been removed.

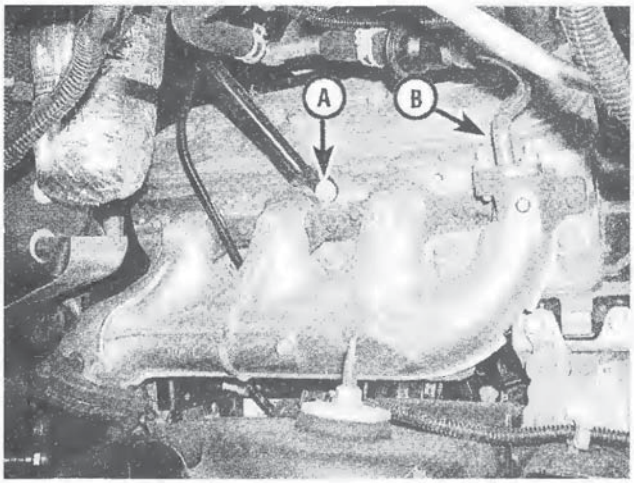
REFITTING

12 Check the manifold for cracks and make sure the bolt threads are clean and undamaged. The manifold and cylinder head mating surfaces must be clean before the manifolds are refitted - use a gasket scraper to remove all carbon deposits and gasket material.

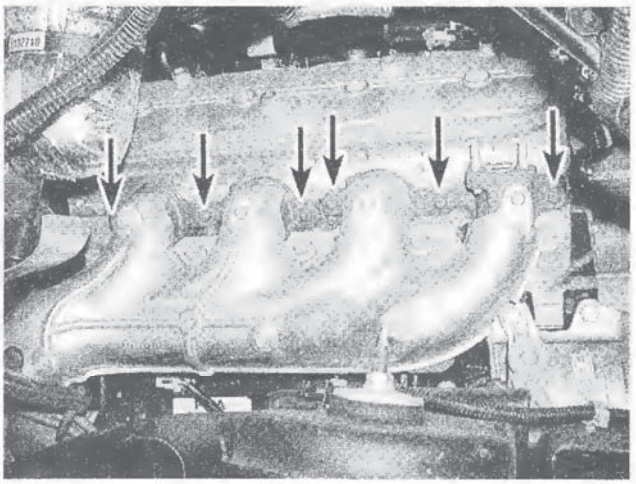
Note: *The cylinder heads are made of aluminium, therefore aggressive scraping is not suggested and will damage the sealing surfaces.*



8.4 Remove the exhaust pipe-to-manifold nuts



8.8 Remove the oil dipstick tube mounting bolt (A) and tube - (B) indicates the secondary air injection check valve and pipe assembly on the right manifold



8.9 Exhaust manifold fastener locations (right side shown, left side similar)

9.2 The vapour vent pipe is retained by two bolts at the front and two bolts at the rear of the cylinder heads (arrows)

9.8 Using a prisebar inserted into an inlet port to break the head loose - do not use excessive force or damage to the head may result

13 Refit the heat shields, then refit the bolts and gaskets onto the manifold. Retaining tabs surrounding the gasket bolt holes should hold the assembly together as the manifold is refitted.

14 Starting at the fourth thread, apply a 3 mm wide band of medium-strength threadlocking compound to the threads of the bolts.

> ***Note:*** *The manufacturer recommends not applying threadlocking compound on the first three threads.*

15 Place the manifold on the cylinder head and refit the mounting bolts finger tight.

16 When tightening the mounting bolts, work from the centre to the ends and be sure to use a torque wrench. Tighten the bolts in two steps to the torque listed in this Chapter's Specifications. If required, bend the exposed end of the exhaust manifold gasket back against the cylinder head.

17 The remaining refitting steps are the reverse of removal.

18 Start the engine and check for exhaust leaks.

9 Cylinder heads - removal and refitting

> ***Note:*** *It will be necessary to purchase a new set of 11 mm head bolts before or during this procedure.*

REMOVAL

Refer to illustrations 9.2 and 9.8

1 Disconnect the cable from the negative terminal of the battery and drain the cooling system (see Chapter 1).

> ***Caution:*** *On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the inlet manifold (see Section 7) and the vapour vent pipe (see illustration).

3 Detach both exhaust manifolds from the cylinder heads (see Section 8).

4 Remove the valve covers (see Section 4).

5 Remove the rocker arms and pushrods (see Section 5).

> ***Caution:*** *Again, as mentioned in Section 5, keep all the parts in order so they are refitted in the same location.*

6 Disconnect the wiring from the back of the alternator, then remove the power steering pump and the power steering pump rear mounting bracket from the left cylinder head. Lay the pump and brackets aside without disconnecting the lines from the steering pump (see Chapter 10). Then remove the wiring harness retaining bolt and the transmission dipstick tube (automatic transmission only) from the rear of the right cylinder head.

7 Loosen the head bolts in 1/4-turn increments in the reverse order of the tightening sequence (see illustration 9.17) until they can be removed by hand.

> ***Note:*** *There will be different length and size head bolts for different locations. Make a note of the different sizes and lengths and where they go when removing the bolts to ensure correct refitting of the new bolts.*

8 Lift the heads off the engine. If resistance is felt, do not prise between the head and block as damage to the mating surfaces will result. To dislodge the head, place a prise bar or long screwdriver into the inlet port and carefully prise the head off the engine (see illustration). Store the heads on blocks of wood to prevent damage to the gasket sealing surfaces.

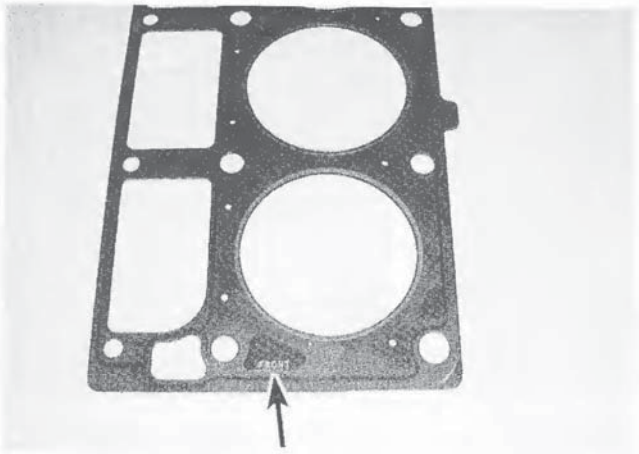
9 Cylinder head disassembly and inspection procedures are covered in detail in Chapter 2, Part E.

REFITTING

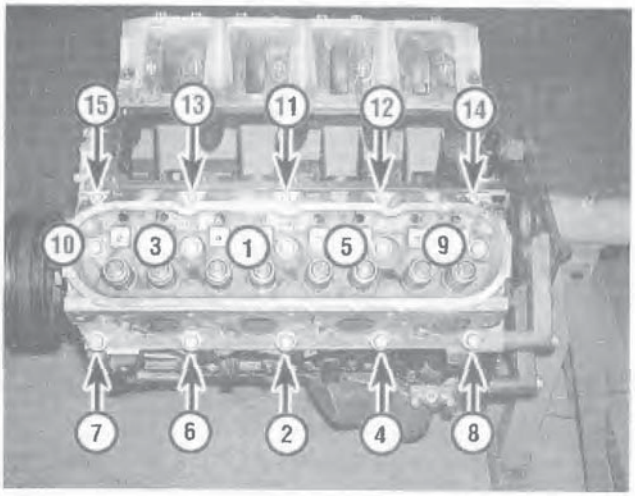
Refer to illustrations 9.14, 9.17 and 9.18

10 The mating surfaces of the cylinder heads and block must be perfectly clean when the heads are refitted. Gasket removal solvents are available at auto parts stores and may prove helpful.

11 Use a gasket scraper to remove all traces of carbon and old gasket material, then wipe the mating surfaces with a cloth saturated with lacquer thinner or acetone.



9.14 Position the head gasket over the dowels at each end of the cylinder head with the mark (arrow) facing the front of the vehicle



9.17 Cylinder head bolt tightening sequence

Note: *The cylinder heads are made of aluminium, therefore aggressive scraping is not suggested and will damage the sealing surfaces.*

If there is oil on the mating surfaces when the heads are refitted, the gaskets may not seal correctly and leaks may develop. When working on the block, use a vacuum cleaner to remove any debris that falls into the cylinders.

12 Check the block and head mating surfaces for nicks, deep scratches and other damage. If damage is slight, it can be removed with emery cloth. If it is excessive, machining may be the only alternative.

13 Use a tap of the correct size to chase the threads in the head bolt holes in the block. If a tap is not available, spray a liberal amount of brake cleaner into each hole. Use compressed air (if available) to remove the debris from the holes.

Warning: *Wear safety glasses or a face shield to protect your eyes when using compressed air.*

Use a wire brush to remove the threadlocking compound from the 8 mm head bolts. Corrosion, sealant and damaged threads will affect torque readings, so be sure the threads are clean.

14 Position the new gaskets over the dowels in the block (see illustration).

15 Carefully position the heads on the block without disturbing the gaskets.

16 Before refitting the 8mm head bolts, coat the threads with a medium-strength threadlocking compound. Then refit the 8mm head bolts (bolts 11 through 15) finger tight.

17 Refit New 11 mm head bolts (bolts 1 through 10) and tighten them finger tight. Following the recommended sequence (see illustration), tighten the bolts in four steps to the torque and angle of rotation listed in this Chapter's Specifications.

Warning: *DO NOT reuse 11mm head bolts - always renew them.*

18 Refit the vapour vent pipe, using new gaskets, onto the cylinder heads (see illustration). Tighten the bolts to the torque listed in this Chapter's Specifications.

19 The remaining refitting steps are the reverse of removal.

20 Add coolant and change the oil and filter (see Chapter 1). Start the engine and check for proper operation and coolant or oil leaks.

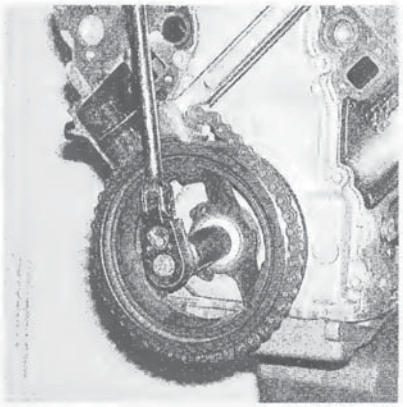
9.18 Be sure to use new gaskets at each cylinder head-to-vent pipe joint - position the O-ring seal over the vent pipe nipple

10 Crankshaft balancer - removal and refitting

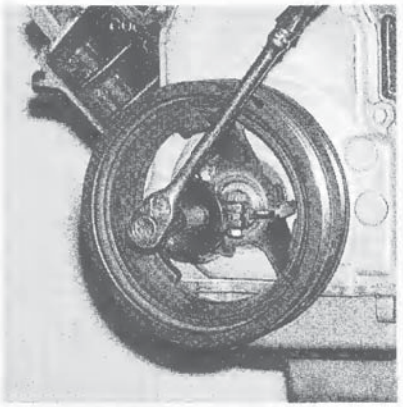
Refer to illustrations 10.5, 10.6 and 10.9

Note: *This procedure requires a special balancer refitting tool (that is available through specialized tool manufacturers only) and a new crankshaft balancer bolt. Read through the entire procedure and obtain the tool and materials before proceeding.*

1 Disconnect the earth (-) lead from the battery.



10.5 Use a strap spanner to hold the crankshaft balancer while removing the centre bolt (a chain-type wrench may be used if you wrap a section of old drivebelt or rag around the balancer first)



10.6 The use of a three jaw puller will be necessary to remove the crankshaft balancer - always place the puller jaws around the hub, not the outer ring

10.9 Before the new crankshaft bolt is fitted and tightened, the balancer must be measured for proper depth - when properly refitted, the balancer hub should extend 2.40 to 4.48 mm past the crankshaft snout

Caution: *On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any prccedure which requires disconnecting the battery (see the front of this manual).*

2 Raise the front of the vehicle and support it securely on jackstands. Then apply the parking brake.

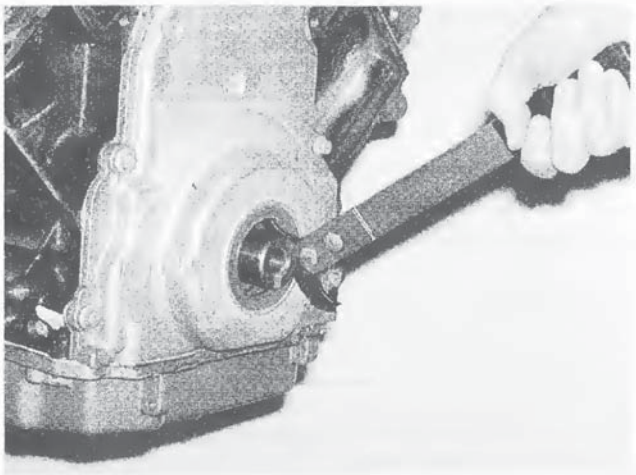
3 Remove the drivebelt (see Chapter 1).

4 Working under the vehicle, remove the transmission oil cooler lines and the power steering cooler lines from the radiator (if equipped).

5 Use a strap spanner around the crankshaft pulley to hold it while using a breaker bar and socket to remove the crankshaft pulley centre bolt (see illustration).

6 Pull the balancer off the crankshaft with a puller (see illustration).

Caution: *The jaws of the puller must only contact the hub of the balancer - not the outer ring.*



11.2 Carefully prise the old seal out of the timing chain cover - don't damage the crankshaft in the process

Note: *A long Allen-head bolt should be inserted into the crankshaft nose for the puller's tapered tip to push against to prevent damage to the crankshaft threads.*

7 Position the crankshaft pulley/balancer on the crankshaft and slide it on as far as it will go. Note that the slot (keyway) in the hub must be aligned with the Woodruff key in the end of the crankshaft.

8 Using the specialized crankshaft balancer refitting tool, press the crankshaft pulley/balancer onto the crankshaft.

9 Refit the old crankshaft balancer bolt and tighten the crankshaft bolt to 330 Nm. Remove the old bolt and measure the distance from the snout of the crankshaft to the balancer hub (see illustration). When properly refitted, the balancer hub should extend 2.40 to 4.48 mm past the crankshaft snout. If the measurement is incorrect, refit the balancer refitting tool and press the balancer on the crankshaft until the measurement is correct.

10 Refit a New crankshaft balancer bolt and tighten it in two steps to the torque and angle of rotation listed in this Chapter's Specifications.

11 The remaining refitting steps are the reverse of removal.

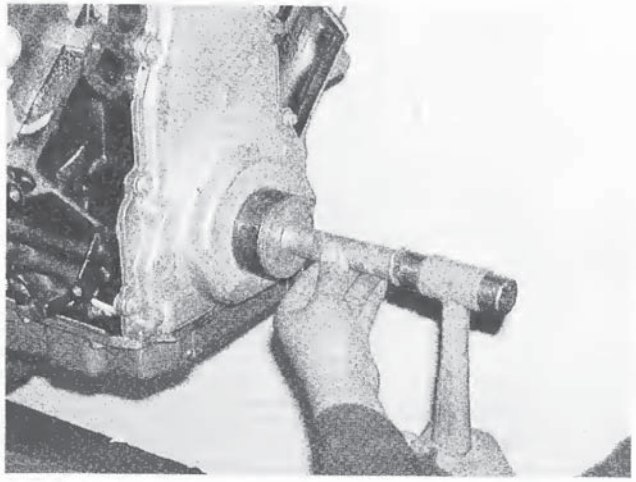
11 Crankshaft front oil seal - removal and refitting

Refer to illustrations 11.2, 11.4 and 11.5

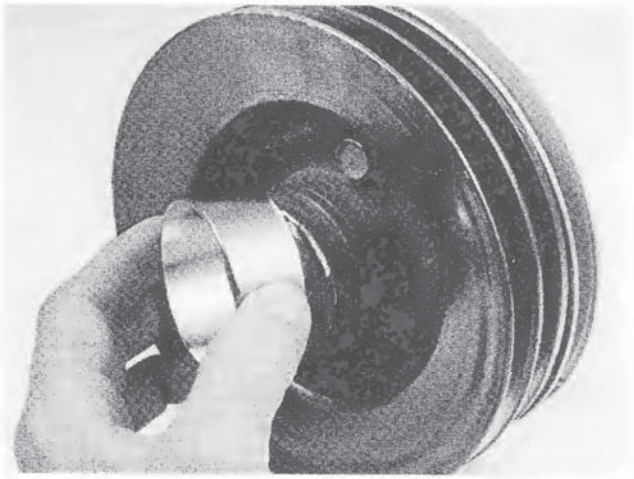
1 Remove the crankshaft balancer (see Section 10).

2 Note how the seal is refitted - the new one must be refitted to the same depth and facing the same way. Carefully prise the oil seal out of the cover with a seal puller or a large screwdriver (see illustration). Be very careful not to distort the cover or scratch the crankshaft! Wrap electrician's tape around the tip of the screwdriver to avoid damage to the crankshaft.

3 If the seal is being renewed with the timing chain cover removed, support the cover on top of two blocks of wood



11.4 Drive the new seal into place with a large socket and hammer



11.5 If the sealing surface of the pulley hub has a wear groove from contact with the seal, repair sleeves are available at most auto parts stores

and drive the seal out from the backside with a hammer and punch.

Caution: *Be careful not to scratch, gouge or distort the area that the seal fits into or a leak will develop.*

4 Apply clean engine oil or multi-purpose grease to the outer edge of the new seal, then refit it in the cover with the lip (spring side) facing IN. Drive the seal into place (see illustration) with a large socket and a hammer (if a large socket isn't available, a piece of pipe will also work). Make sure the seal enters the bore squarely and stop when the front face is at the proper depth.

5 Check the surface on the balancer hub that the oil seal rides on. If the surface has been grooved from long-time contact with the seal, a press-on sleeve may be available to renew the sealing surface (see illustration). This sleeve is pressed into place with a hammer and a block of wood and is commonly available at auto parts stores for various applications.

6 Lubricate the balancer hub with clean engine oil and refit the crankshaft balancer as described in Section 10.

7 The remainder of refitting is the reverse of the removal.

12 Timing chain - removal, inspection and refitting

REMOVAL AND INSPECTION

Refer to illustrations 12.6, 12.9 and 12.12

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Refer to Chapter 1 and drain the cooling system and engine oil.

3 Refer to Chapter 4 and remove the air cleaner and the air inlet resonator from the engine compartment, then refer to Chapter 3 and remove the upper and lower radiator hoses, the cooling fans, drivebelt and the water pump.

4 Remove the crankshaft balancer (see Section 10).

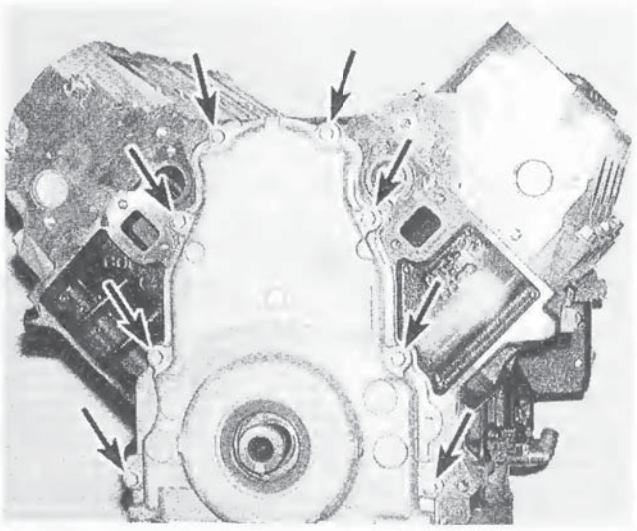
5 Remove the sump (see Section 14).

6 Remove the timing chain cover mounting bolts and separate the timing chain cover from the block (see illustration). The cover may be stuck; if so, use a putty knife to break the gasket seal. Since the cover is made of aluminium it can easily be damaged, so DO NOT attempt to prise it off.

7 Remove the oil pick-up tube and the oil pump (see Section 15).

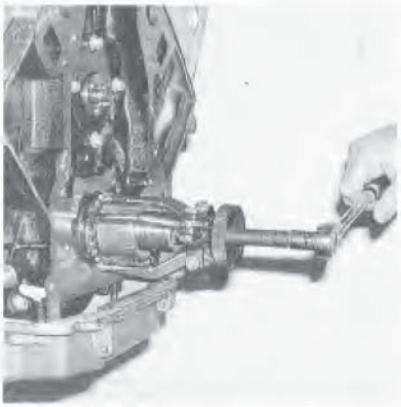
8 Measure the timing chain freeplay. If it is more than 16 mm, the chain and both sprockets should be renewed.

9 Loosen the camshaft sprocket bolts one turn, then screw the crankshaft balancer bolt into the end of the crankshaft and rotate the crankshaft in the normal direction of rotation

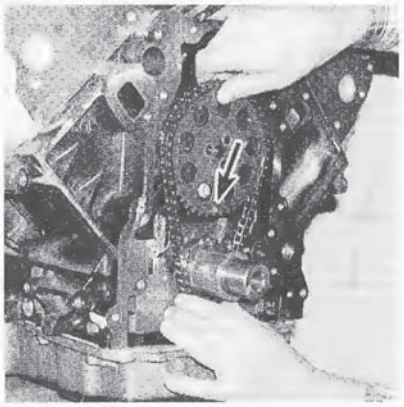


12.6 Timing chain cover mounting bolts (arrows)

12.9 Timing chain alignment marks (arrows) - when properly aligned, the crankshaft gear should be in the 12 o'clock position, the camshaft gear should be in the 6 o'clock position and the number one piston should be at TDC



12.12 The sprocket on the crankshaft can be removed with a two or three-jaw puller



12.15 Slip the chain and camshaft sprocket in place over the crankshaft sprocket with the camshaft sprocket timing mark (arrow) at the bottom

(clockwise) until the timing marks align (see illustration). Verify that the number one piston is at TDC.

10 Remove the three bolts from the end of the camshaft, then detach the camshaft sprocket and chain as an assembly.

11 Inspect the camshaft and crankshaft sprockets for damage or wear.

12 If renewal of the timing chain is necessary, remove the sprocket on the crankshaft with a two-or three-jaw puller, but be careful not to damage the threads in the end of the crankshaft (see illustration).

REFITTING

Refer to illustrations 12.15, 12.19 and 12.20

> ***Note:*** *Timing chains must be renewed as a set with the camshaft and crankshaft sprockets. Never put a new chain on old sprockets.*

13 Use a gasket scraper to remove all traces of old gasket material and sealant from the cover and engine block.

14 Align the crankshaft sprocket with the Woodruff key and press the sprocket onto the crankshaft (if removed) with the vibration damper bolt, a large socket and some washers or tap it gently into place until it is completely seated.

> ***Caution:*** *If resistance is encountered, do not hammer the sprocket onto the crankshaft. It may eventually move onto the shaft, but it may be cracked in the process and fail later, causing extensive engine damage.*

15 Loop the new chain over the camshaft sprocket, then turn the sprocket until the timing mark is at the bottom (see illustration). Mesh the chain with the crankshaft sprocket and position the camshaft sprocket on the end of the camshaft. If necessary, turn the camshaft so the dowel in the camshaft fits into the hole in the sprocket with the timing mark in the 6 o'clock position (see illustration 12.9). When the chain is refitted, the timing marks MUST align as shown.

16 Apply a thread locking compound to the camshaft sprocket bolt threads and tighten the bolts to the torque listed in this Chapter's Specifications.

17 Lubricate the chain with clean engine oil.

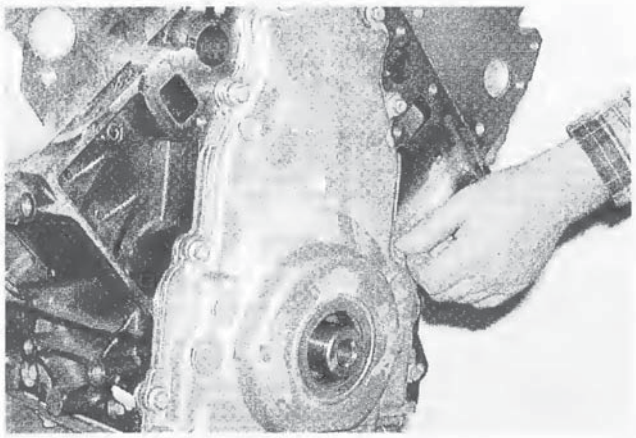
18 Refit the oil pump and the oil pick up tube onto the engine (see Section 15). Now would be a good time to renew the crankshaft front oil seal (see Section 11).

19 Refit the timing chain cover on the engine loosely using a new gasket (see illustration).

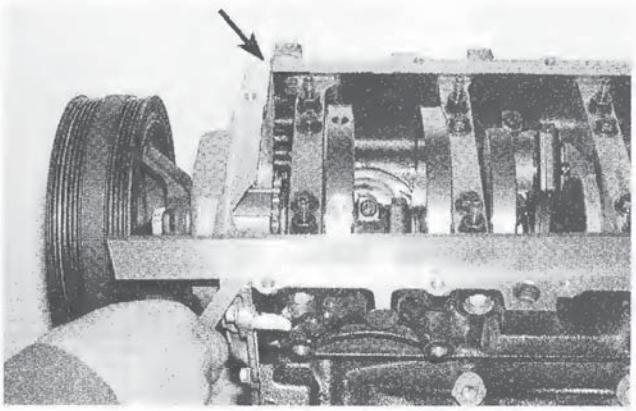
20 The manufacturer recommends that it is mandatory to use a front cover alignment tool when refitting the front cover, however at the time this manual was printed the tools were unobtainable. If the tool is not available, follow the alternate procedure outlined below:

a) Refit the crankshaft balancer on the engine as described in Section 10. This Step will align the front oil seal with the balancer hub.

b) Place a straightedge on the engine block sump rail. Measure the distance on each side of the block from the sump rail to the timing chain cover with a feeler gauge (see illustration). This Step measures the difference between the sealing surface of the sump and the sealing surface of the timing chain cover in relationship to each other.



12.19 Refit the front cover with a new gasket onto the engine block LOOSELY - the cover must be aligned properly before final refitting



12.20 With the crankshaft balancer in place and the front cover bolts refitted LOOSELY, measure the distance between the sump rail and the front cover sealing surface on each side (arrows) - then adjust the cover so the measurements are even on both sides before tightening the cover bolts

c) *Tilt the front timing cover as necessary to achieve an even measurement on each side. This Step properly aligns the front timing cover to sump sealing surfaces. Typically 0 to 0.25 mm is an acceptable tolerance.*

> ***Note:*** *Ideally the timing chain cover should be flush with the sump rail, but because of the differences in seal thickness, this may not always be obtainable. That is why there is a tolerance 0 to 0.25 mm. Always let the front seal centre itself around the crankshaft balancer hub and tilt the cover from side to side to even up the measurement at both sump rails. Never push downward on the front timing cover in an attempt to make the sump sealing surface flush, as this will distort the front oil seal and eventually lead to an oil leak!*

d) *With the timing chain cover properly aligned, tighten the cover bolts to the torque listed in this Chapter's Specifications.*

21 Apply a thin layer of RTV sealant to the areas where the timing chain cover and cylinder block meet, then refit the sump as described in Section 14.

22 The remaining refitting steps are the reverse of removal.

23 Add coolant and oil to the engine (see Chapter 1). Run the engine and check for oil and coolant leaks.

13 Camshaft and lifters - removal and refitting

> ***Note 1:*** *The camshaft should always be thoroughly inspected before refitting and camshaft endplay should always be checked prior to camshaft removal. Camshaft and lifter inspection procedures for the 2nd generation V8 engine are identical to inspection procedures on the 1st generation V8 engine, therefore refer to Chapter 2C for the Camshaft and lifter inspection procedures.*

> ***Note 2:*** *If the camshaft is being renewed, always fit new lifters as well. Do not use old lifters on a new camshaft.*

> ***Note 3:*** *6.0 litre models have slightly different hydraulic lifters fitted than the 5.7 litre. They are for a system called Displacement on Demand (DoD). The system is not activated on models in Australia, but all of the hardware is in place for it. The procedures to remove the hydraulic lifters are the same. However, some of the illustrations of the lifters and the valley cover in this book may appear slightly different to the 6.0 litre engine.*

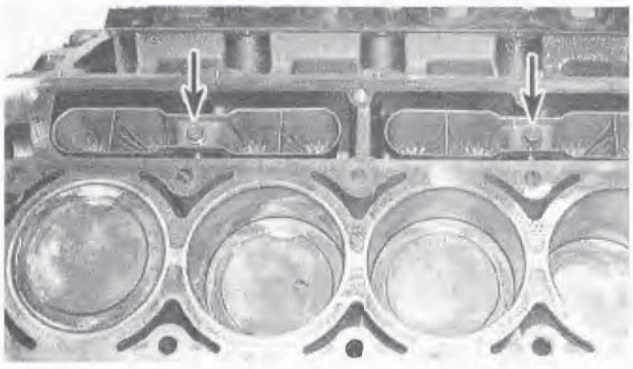
REMOVAL

Refer to illustrations 13.2a, 13.2b and 13.4

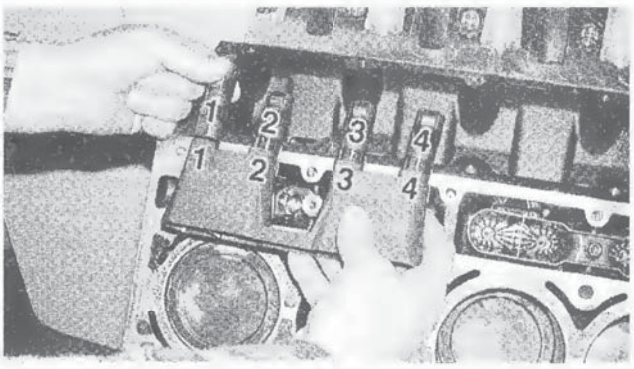
1 Refer to the appropriate Sections and remove the inlet manifold, valve covers, rocker arms, pushrods, timing chain and the cylinder heads. Also remove the radiator and air conditioning condenser (see Chapter 3) and the camshaft position sensor (see Chapter 6).

2 Before removing the lifters, arrange to store them in a clearly labeled box to ensure that they're refitted in their original locations. Remove the lifter retainers and lifters and store them where they won't get dirty (see illustrations). DO NOT attempt to withdraw the camshaft with the lifters in place.

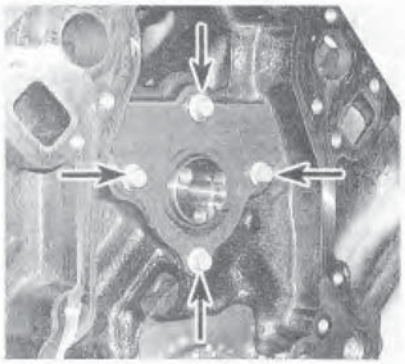
3 If the lifters are built up with gum and varnish they may not come out with the retainer. If so, there are several ways to extract the lifters from the bores. A special tool designed to grip and remove lifters is manufactured by many tool companies and is widely available, but it may not be required in every case. On newer engines without a lot of varnish buildup, the lifters can often be removed with a small magnet or even with your fingers. A machinist's scribe with



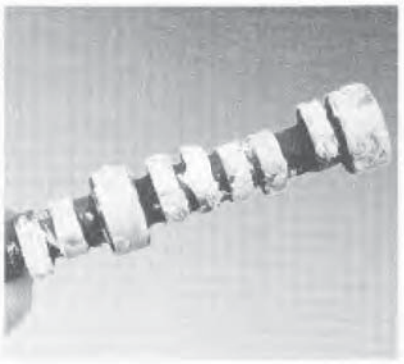
13.2a The roller lifters are held in place by retainers - remove the retainer bolts, then remove the retainers and the lifters as an assembly - note that each retainer houses four individual lifters and they must be refitted back in their original locations if they're going to be reused



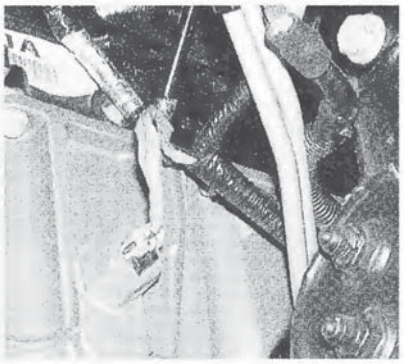
13.2b Once the lifters and retainers are removed from the block they can be marked (for location and refitting purposes) and inspected



13.4 Remove the bolts (arrows) and take off the camshaft retainer plate, noting which side faces the block



13.7 Be sure to apply camshaft assembly lube to the cam lobes and bearing journals before refitting the camshaft



14.5 The oil level sensor is located on the passenger side of the sump

a bent end can be used to pull the lifters out by positioning the point under the retainer ring in the top of each lifter.

***Caution:** Don't use pliers to remove the lifters unless you intend to renew them. The pliers will damage the precision machined and hardened lifters, rendering them useless.*

4 Remove the bolts and the camshaft retainer plate, noting which direction faces the block (see illustration).

5 Thread three long bolts into the camshaft sprocket bolt holes to use as a "handle" when removing the camshaft from the block.

6 Carefully pull the camshaft out. Support the cam near the block so the lobes don't nick or gouge the bearings as it's withdrawn.

REFITTING

Refer to illustration 13.7

7 Lubricate the camshaft bearing journals and cam lobes with camshaft and lifter assembly lube (see illustration).

8 Slide the camshaft into the engine. Support the cam near the block and be careful not to scrape or nick the bearings.

9 Turn the camshaft until the dowel pin is in the 3 o'clock position, and refit the camshaft thrust plate, tighten the bolts to the torque listed in this Chapter's Specifications. Make sure the gasket surface on the camshaft thrust plate and the engine block are free from oil and dirt.

10 Refit the timing chain and sprockets (see Section 12). Also refit the camshaft position sensor (see Chapter 6).

11 Lubricate the lifters with clean engine oil and refit them in the lifter retainers. Be sure to align the flats on the lifters with the flats in the lifter retainers. Refit the retainer and lifters into the engine block as an assembly. If the original lifters are being refitted, be sure to return them to their original locations. If a new camshaft is being fitted, fit new lifters as well. Tighten the lifter retainer bolts to the torque listed in this Chapter's Specifications.

12 The remaining refitting steps are the reverse of removal.

13 Before starting and running the engine, change the oil and fit a new oil filter (see Chapter 1).

14 Sump - removal and refitting

REMOVAL

Refer to illustration 14.5

1 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with a Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery.*

2 Raise the vehicle and support it securely on jackstands, then refer to Chapter 1 and drain the engine oil and remove the oil filter. Also remove the air cleaner housing and the air inlet resonator (see Chapter 4).

3 Disconnect the front exhaust Y pipe from the engine and the exhaust system and remove it from the vehicle. This step is not absolutely necessary, but it will help facilitate removal of the sump.

4 Remove the starter motor (see Chapter 5). Also remove the plastic bellhousing covers on each side of the bellhousing.

5 Remove any wiring harness brackets connected to the sump and the brackets on the passenger side of the sump securing the transmission oil cooler lines (if equipped). Also disconnect the electrical connector from the oil level sensor (see illustration).

6 Attach an engine hoist to the engine from above and raise the engine slightly to allow removal of the engine mount through bolts or the engine mount to cradle bolts (see Section 18).

7 Raise the engine approximately 75 mm.

***Caution:** When lifting the engine check that no upper engine components or wiring harnesses are hitting the edge of the cowl.*

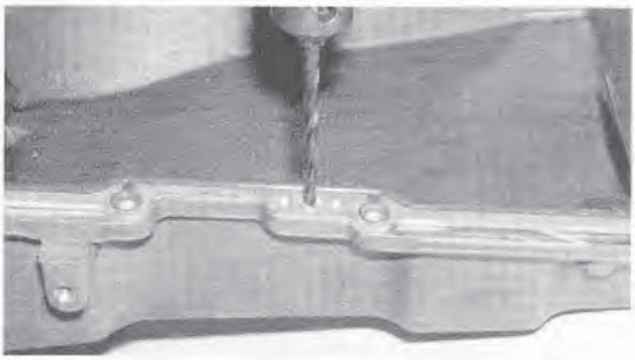
8 Unbolt the shock absorbers from the lower control arms, then loosen the steering shaft coupler from the steering gear (see Chapter 10). Loosen the (six) front suspension cradle bolts four to five turns. This will lower the front suspension cradle away from the body and will allow clearance for removal of the sump.

***Caution:** Do not loosen the front suspension cradle bolts more than five turns without the use of floor jack or jackstands to support the cradle or injury may occur.*

9 Remove the transmission to sump bolts (see Chapter 7).

10 If the vehicle is equipped with an engine oil cooler, remove the engine oil cooler lines and adapter from the driver's side of the sump.

11 Remove the access plugs covering the nuts at the rear of the sump (if equipped).



14.13 The manufacturer uses rivets to hold the gasket to the sump during assembly - carefully drill them out (it isn't necessary to rivet the new gasket to the sump)

12 Remove all the sump bolts, then lower the sump from the engine. The sump will probably stick to the engine, so strike the sump with a rubber mallet until it breaks the gasket seal.

> ***Caution:*** *Before using force on the sump, be sure all the bolts have been removed. Carefully slide the sump down and out, to the rear.*

REFITTING

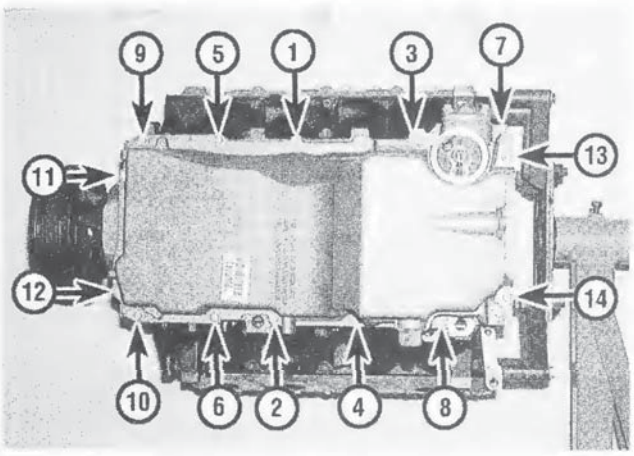
Refer to illustrations 14.13 and 14.16

13 Drill out the rivets securing the sump gasket to the sump and remove the old gasket (see illustration). Wash out the sump with solvent.

14 Thoroughly clean the mounting surfaces of the sump and engine block of old gasket material and sealer. Wipe the gasket surfaces clean with a rag soaked in lacquer thinner, acetone or brake system cleaner.

15 Apply a 3mm wide, 20 mm long bead of RTV sealant to the corners of the block where the front cover and the rear cover meet the engine block. Then attach the new gasket to the sump, refit the sump and tighten the bolts finger-tight. Be sure the oil gallery passages in the sump and the gasket are aligned properly.

16 The alignment of the rear face of the aluminium sump to the rear of the block is important. Measure between the rear face of the sump and the front face of the transmission bellhousing with feeler gauges. Clearance should ideally be flush, but a gap of up to 0.25 mm is allowable. If the clearance is OK, tighten the sump bolts/studs in sequence to the torque listed in this Chapter's Specifications (see illustration). If the clearance is not acceptable, refit the two lower sump-to-bellhousing bolts and tighten them finger tight. This should draw the sump flush with the bellhousing.



14.16 Sump TIGHTENING sequence

17 The remainder of refitting is the reverse of removal.

18 Add the proper type and quantity of oil (see Chapter 1), start the engine and check for leaks before placing the vehicle back in service.

15 Oil pump - removal, inspection and refitting

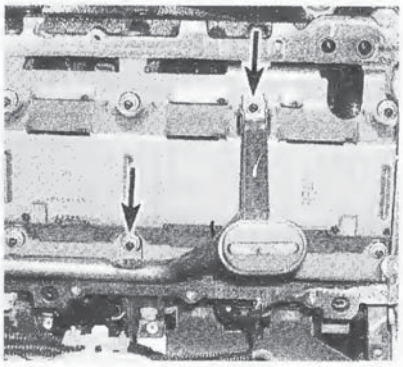
REMOVAL

Refer to illustrations 15.2a, 15.2b and 15.3

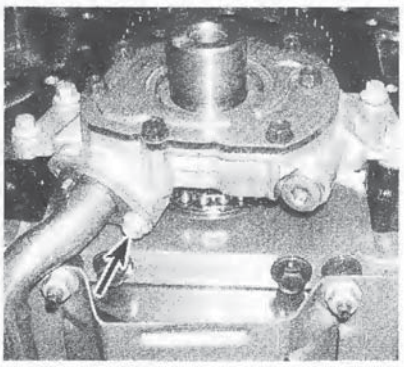
1 Refer to the Section 12, Steps 1 through 6 and remove the timing chain cover.

2 Remove the oil pump pick-up tube mounting nuts and bolts and lower the pick-up tube and screen assembly from the vehicle (see illustrations).

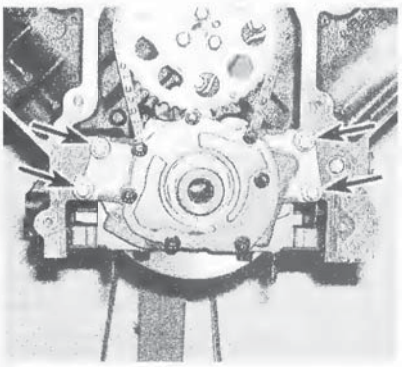
3 Remove the oil pump retaining bolts and slide the pump off the end of the crankshaft (see illustration).



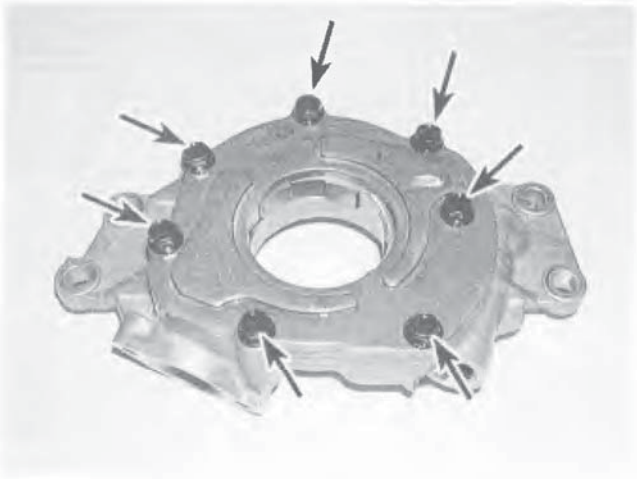
15.2a Oil pick-up tube-to-main stud retaining nuts (arrows)



15.2b Remove the bolt (arrow) securing the oil pick-up tube to the oil pump and remove it from the engine



15.3 Oil pump mounting bolts (arrows)



15.4 Oil pump cover-to-oil pump housing mounting bolts (arrows)

15.8 Always fit a new O-ring on the oil pump pick up tube

INSPECTION

Refer to illustration 15.4

4 Remove the oil pump cover and withdraw the rotors from the pump body (see illustration). Clean the components with solvent, dry them thoroughly and inspect for any obvious damage. Also check the bolt holes for damaged threads and the splined surfaces on the crankshaft sprocket for any apparent damage. If any of the components are scored, scratched or worn, renew the entire oil pump assembly. There are no serviceable parts currently available.

REFITTING

Refer to illustration 15.8

5 Prime the pump by pouring clean motor oil into the pick-up tube hole, while turning the pump by hand.

6 Position the oil pump over the end of the crankshaft and align the teeth on the crankshaft sprocket with the teeth on the oil pump drive gear. Making sure the pump is fully seated against the block.

7 Refit the oil pump mounting bolts and tighten them to the torque listed in this Chapter's Specifications.

8 Refit a new O-ring on the oil pump pick-up tube, then fasten it to the oil pump and the engine block main studs (see illustration).

> ***Caution:*** *Be absolutely certain that the pick-up tube-to-oil pump bolts are properly tightened so that no air can be sucked into the oiling system at this connection.*

9 Refit and align the timing chain cover, then refit the sump. Refer to Sections 12 and 14 for the refitting procedures.

10 The remainder of refitting is the reverse of removal.

11 Add oil and coolant as necessary. Run the engine and check for oil and coolant leaks. Also check the oil pressure as described in Chapter 2E.

16 Flywheel/driveplate - removal and refitting

The flywheel/driveplate renewal for 2nd generation V8 engine is identical to the flywheel/driveplate renewal procedure for the V6 engines. Refer to Chapter 2 Part A for the procedure and use the torque figures in this Chapter's Specifications.

17 Rear main oil seal - renewal

Refer to illustrations 17.3 and 17.4

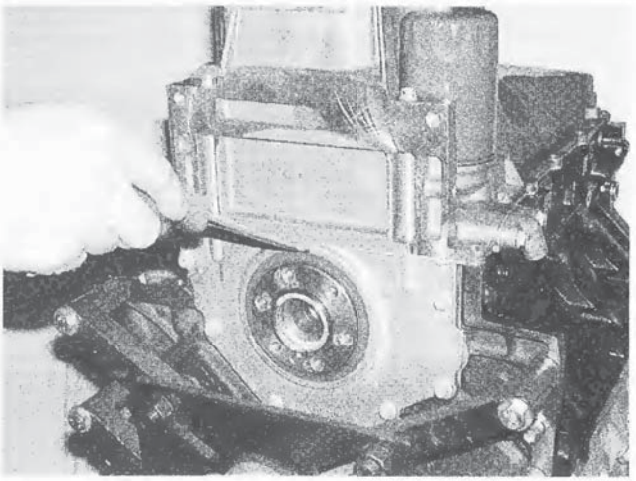
> ***Note:*** *If you're refitting a new rear seal during a complete engine overhaul, refer to the procedure in Chapter 2E.*

1 Remove the transmission (see Chapter 7).

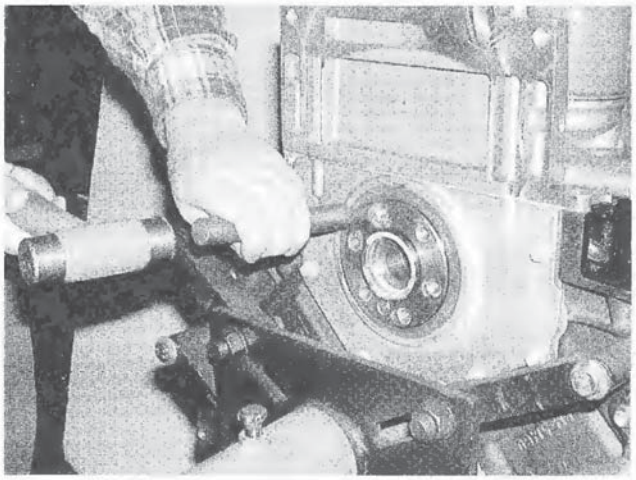
2 Remove the flywheel/driveplate (see Section 16).

3 Prise the oil seal from the rear cover with a screwdriver (see illustration). Be careful not to nick or scratch the crankshaft or the seal bore. Be sure to note how far it's recessed into the housing bore before removal so the new seal can be refitted to the same depth. Thoroughly clean the seal bore in the block with a shop towel. Remove all traces of oil and dirt.

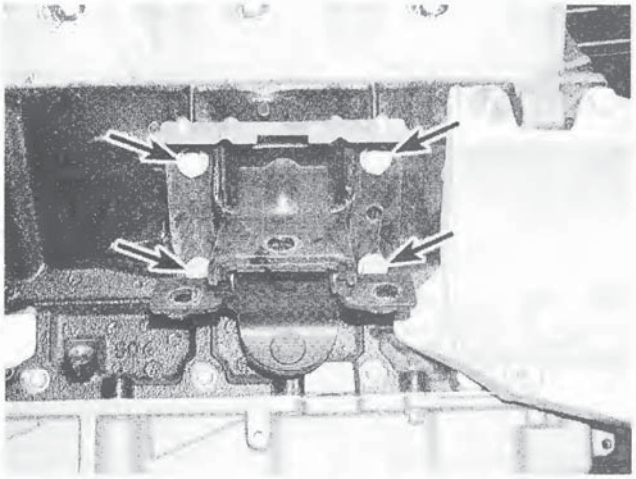
4 Lubricate the outside diameter of the seal and fit the seal over the end of the crankshaft. Make sure the lip of the



17.3 Carefully prise the old seal out with a screwdriver at the notches provided in the rear cover



17.4 The rear oil seal can be pressed into place with a seal fitting tool, a section of pipe or a blunt object (shown here) - in any case be sure the seal is fitted squarely into the seal bore and flush with the rear cover



18.11 Engine mount-to-engine block mounting bolts (arrows)

seal points toward the engine. Preferably, a seal fitting tool (available at most auto parts store) should be used to press the new seal back into place. If the proper seal fitting tool is unavailable, use a large socket, section of pipe or a blunt tool and carefully drive the new seal squarely into the seal bore and flush with the rear cover (see illustration).

5 Refit the flywheel/driveplate (see Section 16).

6 Refit the transmission (see Chapter 7).

18 Engine mounts - check and renewal

1 Engine mounts seldom require attention, but broken or deteriorated mounts should be renewed immediately or the added strain placed on the driveline components may cause damage.

CHECK

2 During the check, the engine must be raised slightly to remove the weight from the mounts.

3 Raise the vehicle and support it securely on jackstands, then position the jack under the engine sump. Place a large block of wood between the jack head and the sump, then carefully raise the engine just enough to take the weight off the mounts. Do not use the jack to support the entire weight of the engine.

4 Check the mounts to see if the rubber is cracked, hardened or separated from the metal plates. Sometimes the rubber will split right down the centre. Rubber preservative or WD-40 can be applied to the mounts to slow deterioration.

5 Check for relative movement between the mount plates and the engine or frame (use a large screwdriver or prisebar to attempt to move the mounts). If movement is noted, check the tightness of the mount fasteners first before condemning the mounts. Usually when engine mounts are broken, they are very obvious as the engine will easily move away from the mount when pried or under load.

RENEWAL

Refer to illustration 18.11

6 Disconnect the cable from the negative terminal of the battery, then raise the vehicle and support it securely on jackstands.

Caution: *On models equipped with the Theftlock audio system, be sure the lockout feature is turned off before performing any procedure which requires disconnecting the battery (see the front of this manual).*

7 Remove the air cleaner housing and the air inlet resonator from the engine compartment (see Chapter 4).

8 If you're removing the drivers side mount remove the engine mount-heat shield from the engine compartment. If you're removing the passenger side mount, disconnect the oil level sensor electrical connector from the sump, then remove the starter and detach the negative battery cable from the engine block (see Chapter 5).

9 Working below the vehicle, remove the engine mount to front suspension cradle bolts. There are four bolts securing each mount to the cradle.

10 Attach an engine hoist to the top of the engine for lifting; do not use a jack under the sump to support the entire weight of the engine or the oil pump pick-up could be damaged.

Note: *If a hoist is not available, casting lugs on each side of the engine block can be used to support the entire weight of the engine while the engine mounts are being renewed.*

11 Raise the engine slightly until the engine mount can be unbolted from the block. Unbolt the mount from the engine block and remove it from the vehicle (see illustration). Separate the upper and lower mount on the bench.

12 Refitting is the reverse of removal. Use non-hardening thread-locking compound on the mount bolts and be sure to tighten them to the torque listed in this Chapter's Specifications.

Notes

Chapter 2
Engine

Part E. General engine overhaul procedures

Contents

Specifications

3.8 litre V6 engine

General

Displacement	3,791 cc
Bore and stroke	96.5 x 86.3 mm
Compression ratio	
Non-supercharged engine	9.35:1
Supercharged engine	8.5:1
Firing order	1-6-5-4-3-2
Oil pressure, warm	275 kPa at 1850 rpm
Compression, minimum	690 kPa
Maximum compression variation	30%

Cylinder head

Warpage limit	0.075 mm per 150 mm span
Minimum thickness at pads	1.12 mm

Valves and related components

Margin width (minimum)	0.63 mm
Seat angle	45-degrees
Face angle	45-degrees
Stem-to-guide clearance	0.04 to 0.25 mm
Spring force	
Closed	316 to 351 N @ 43.7 mm
Open	970 to 1,059 N @ 32.4 mm
Spring refitted height	43.7 to 44.7 mm

Crankshaft and connecting rods

Connecting rod journal	
Diameter	57.117 to 57.147 mm
Bearing oil clearance	0.023 to 0.053 mm
Maximum taper/out-of-round	0.008 mm
Connecting rod side clearance (endplay)	0.10 to 0.50 mm
Main bearing journal	
Diameter	63.470 to 63.495 mm
Bearing oil clearance	0.023 to 0.053 mm
Maximum taper/out-of-round	0.008 mm
Crankshaft endplay (at thrust bearing)	0.08 to 0.28 mm

Engine block

Cylinder bore	
Diameter	96.507 to 96.533 mm
Out-of-round limit	0.010 mm
Taper limit	0.013 mm
Deck surface flatness	0.08 mm

3.8 litre V6 engine (continued)

Pistons and rings

Piston-to-bore clearance limits ..... 0.010 to 0.051 mm
Piston ring end gap
- Top ring ..... 0.305 to 0.559 mm
- Second ring ..... 0.762 to 1.016 mm
- Oil control rails ..... 0.254 to 0.762 mm

Piston ring side clearance
- Compression rings ..... 0.039 to 0.079 mm
- Oil control ring ..... 0.023 to 0.201 mm

Piston measuring point ..... 3.9 mm below top of piston

Camshaft

Bearing journal diameter ..... 46.858 to 46.893 mm
Bearing oil clearance
- Numbers 1 and 4 ..... 0.041 to 0.112 mm
- Numbers 2 and 3 ..... 0.049 to 0.119 mm

Lobe lift
- Inlet ..... 6.56 mm
- Exhaust ..... 6.48 mm

Camshaft endplay ..... 0.04 to 0.26 mm

Balance shaft

Endplay ..... 0 to 0.203 mm
Radial play
- Front ..... 0 to 0.028 mm

Rear bush clearance ..... 0.025 to 0.0.130 mm
Drive gear lash ..... 0.050 to 0.127 mm
Bearing bore diameter
- Front ..... 51.973 to 51.999 mm
- Rear ..... 38.12 to 38.19 mm

Torque specifications*

	Nm
Main Bearing cap bolts	
Step 1	70
Step 2	Loosen 360-degrees
Step 3	20
Step 4	40
Step 5	Tighten an additional 35-degrees
Step 6	Tighten an additional 35-degrees
Step 7	Tighten an additional 35-degrees
Main bearing cap side bolts	
Step 1	12 to 18
Step 2	Tighten an additional 45-degrees
Connecting rod bolts	
Step 1	24 to 30
Step 2	Tighten an additional 50-degrees

Refer to Chapter 2, Part A for additional torque specifications

3.6 litre V6 engine

General

Displacement ..... 3,565 cc
Bore and stroke ..... 94.0 x 85.6 mm
Firing order 1-2-3-4-5-6
Oil pressure, warm ..... 138 kPa at 2000 rpm

Cylinder head

Warpage limit
- To engine block ..... 0.05 mm
- To inlet manifold ..... 0.05 mm
- To exhaust manifold ..... 0.25 mm

Valves and related components

Valve face
- Angle ..... 44.25 degrees
- Runout ..... 0.038 mm
- Width
  - Exhaust ..... 2.750 mm
  - Intake ..... 2.180 mm

Valve head diameter
- Exhaust ..... 30.470-30.730 mm
- Intake ..... 36.830 to 37.090 mm

Valve installed height ..... 35.26 to 36.69 mm
Valve length
- Exhaust ..... 97.110 mm
- Intake ..... 101.230 mm

Valve stem diameter
- Standard ..... 5.955 to 5.975 mm
- Oversize ..... 6.013 to 6.033 mm

Valve stem to guide clearance ..... 0.025 to 0.065 mm
Hydraulic lifter diameter ..... 11.986 to 12.000 mm
Hydraulic lifter to bore clearance ..... 0.037 to 0.041 mm
Valve spring
- Free length ..... 42.500 to 45.500 mm
- Installed height
  - Closed ..... 35.000 mm
  - Open ..... 24.000 mm

Crankshaft and connecting rods

Connecting rod journal
- Diameter ..... 55.992 to 56.008 mm
- Out of round ..... 0.005 mm
- Taper ..... 0.005 mm
- Width
  - Standard ..... 22.000 mm
  - Limit ..... 21.920 to 22.080 mm

Crankshaft
- End play ..... 0.100 to 0.330 mm
- Main bearing clearance ..... 0.010 to 0.060 mm
- Main journal diameter ..... 67.992 to 68.008 mm
- Main journal out-of-round ..... 0.005 mm
- Main journal taper ..... 0.005 mm
- Rear flange runout ..... 0.025 mm
- Thrust bearing clearance ..... 0.076 to 0.305 mm
- Thrust surface runout ..... 0.040 mm

Engine block

Cylinder bore
- Diameter ..... 93.992 to 94.008 mm
- Out-of-round limit ..... 0.013 mm

Main bearing bore diameter ..... 72.867 to 72.881 mm
Deck surface flatness ..... 0.05 mm

Pistons and rings

Piston-to-bore clearance limits ..... 0.026 to 0.052 mm
Piston ring end gap
- Top ring ..... 0.150 to 0.300 mm
- Second ring ..... 0.280 to 0.480 mm
- Oil control rails ..... 0.150 to 0.600 mm

Piston ring side clearance
- Top ring ..... 0.030 to 0.065 mm
- Second ring ..... 0.015 to 0.060 mm
- Oil control rails ..... 0.030 to 0.170 mm

Camshaft

Bearing journal diameter
- Front number 1 ..... 34.936 to 34.960 mm
- Middle and rear number 2 to 4 ... 26.936 to 26.960 mm

Bearing oil clearance ..... 0.040 to 0.084
Lobe lift
  Inlet
    165 kW engine ..... 6.2 mm
    190 kW engine ..... 6.5 mm
  Exhaust ..... 6.6 mm
Camshaft endplay ..... 0.045 to 0.215 mm

Torque specifications* **Nm**
Main bearing cap bolts
  Step 1 20
  Step 2 ..... Tighten an additional 80-degrees
Main bearing cap side bolts
  Step 1 30
  Step 2 ..... Tighten an additional 60-degrees
Connecting rod bolts
  Step 1 30
  Step 2 ..... Loosen completely
  Step 3 25
  Step 4 ..... Tighten an additional 110-degrees

**Refer to Chapter 2, Part B for additional torque specifications*

5.0 litre V8 engine

General

Displacement ..... 4.983 cc
Compression ratio 8.8:1
Firing order 1-2-7-8-4-5-6-3
Oil pressure, hot
  At 500 rpm ..... 48 kPa minimum
  At 2000 rpm ..... 276 to 414 kPa
Maximum compression variation ..... 138 kPa

Cylinder head

Warpage limit ..... 0.10 mm
Minimum thickness at pads ..... 25.95 mm

Valves and related components

Margin width (minimum) ..... 0.63 mm
Seat angle 46-degrees
Face angle 45-degrees
Stem-to-guide clearance ..... 0.025 to 0.068 mm
Spring force at 45.2 mm ..... 338 to 373 N
Spring free height ..... 51.56 mm (approx.)

Crankshaft and connecting rods

Connecting rod journal
  Diameter ..... 53.950 to 53.975 mm
  Bearing oil clearance
    New ..... 0.018 to 0.056 mm
    Maximum ..... 0.09 mm
  Maximum taper/out-of-round ..... 0.0381 mm
  Connecting rod side
    clearance (endplay) ..... 0.203 to 0.356 mm
Main bearing journal
  Diameter ..... 60.90 to 60.93 mm
  Bearing oil clearance
    New ..... 0.020 to 0.061 mm
  Maximum taper/out-of-round ..... 0.0254 mm
  Crankshaft endplay (at thrust bearing)
    New ..... 0.051 to 0.153 mm
    Maximum ..... 0.250 mm

Engine block

Cylinder bore
  Diameter ..... 101.600 to 101.676 mm
  Out-of-round limit ..... 0.0762 mm
  Taper limit ..... 0.1270 mm

Pistons and rings

Piston diameter ..... 101.572 to 101.648 mm
Piston-to-bore clearance ..... 0.020 to 0.036 mm
Piston ring end gap
  Top ring ..... 0.279 to 0.533 mm
  Second ring ..... 0.254 to 0.508 mm
  Oil control rails ..... 0.38 to 1.39 mm
Piston ring side clearance,
  compression rings ..... 0.03 to 0.08 mm
Piston measuring point ..... 6.5 mm below top of piston

Camshaft

Bearing journal diameter
  No. 1 and no. 2 ..... 47.960 to 47.978 mm
  No. 3 and no. 4 ..... 47.452 to 47.478 mm
  No. 5 ..... 40.107 to 40.132 mm
Bearing oil clearance
  New ..... 0.04 to 0.09 mm
  Maximum ..... 0.14 mm
Lobe lift ..... 6.49 to 6.6.75 mm
Camshaft endplay ..... 0.51 to 0.356 mm

Torque specifications* **Nm**
Main bearing cap bolts ..... 81 to 95
Connecting rod nuts ..... 56 to 64

** Refer to Chapter 2, Part C for additional torque specifications.*

5.7 litre Generation III and 6.0 litre Generation IV V8 engine

General

Displacement
  5.7 litre ..... 5,667 cc
  6.0 litre ..... 5,967 cc
Compression ratio 10.1:1
Cylinder compression pressure ..... 690 kPa
Maximum variations between cylinders ... 25-percent from the highest reading
Firing order 1-8-7-2-6-5-4-3
Oil pressure, hot
  At 1000 rpm ..... 45 kPa minimum
  At 2000 rpm ..... 125 kPa
  At 4000 rpm ..... 165 kPa

Cylinder head

Warpage limit ..... 0.080 mm per 150 mm span

Valves and related components

Seat angle 46-degrees
Face angle 45-degrees
Valve seat
  Inlet width ..... 1.020 mm (maximum)
  Exhaust width ..... 1.780 mm (maximum)
  Runout ..... 0.050 mm (maximum)

5.7 litre Generation III and 6.0 litre Generation IV V8 engine (continued)

Valves and related components (continued)

Stem-to-guide clearance	
Original valves	0.025 to 0.066 mm
Replacement valves	0.093 mm
Stem Diameter	
Original valves	7.955 to 7.976 mm
Replacement valves	7.95 mm
Valve spring	
Spring force (closed valve) at 45.75 mm	
5.7 litre	340 N
6.0 litre	400 N
Spring force (open valve) at 33.55 mm	980 N
Spring free height	
5.7 litre	52.9 mm
6.0 litre	54.9 mm
Fitted height	45.75 mm

Crankshaft and connecting rods

Crankshaft end play	0.040 to 0.200 mm
Connecting rod journal	
Diameter	
5.7 litre	53.318 to 53.338 mm
6.0 litre (minimum)	53.308 mm
Bearing oil clearance	0.023 to 0.076 mm
Taper/out-of-round	
5.7 litre	0.005 mm
6.0 litre (maximum)	0.010 mm
Service limit taper/out-of-round	0.01 mm
Connecting rod side clearance (endplay)	0.110 to 0.510 mm
Main bearing journal	
Diameter	64.993 to 65.007 mm
Bearing oil clearance	0.020 to 0.065 mm
Taper	0.010 mm
Taper (maximum)	0.020 mm
Out-of-round	0.003 mm
Out-of-round (maximum)	0.008 mm
Runout (at rear flange)	0.050 mm

Engine block

Cylinder bore	
Diameter	99.0 to 99.018 mm
Out-of-round and taper limit	0.018 mm (maximum)

Pistons and rings

Piston diameter	98.964 to 98.982 mm
Piston-to-bore clearance	0.027 to 0.023 mm (maximum)
Piston ring end gap	
Top ring	0.230 to 0.380 mm (maximum)
Second ring	0.440 to 0.640 mm (maximum)
Oil control rails	0.180 to 0.690 mm (maximum)
Piston ring side clearance	
Top ring	0.040 to 0.085 mm (maximum)
Second ring	0.040 to 0.080 mm (maximum)
Oil control rails	0.010 to 0.220 mm (maximum)
Piston measuring point	11 mm from bottom of skirt, at right angles to pin bore

Camshaft

Journal diameter	54.99 to 55.04 mm
Bearing journal diameter out-of-round	0.025 mm (maximum)
Lobe lift	7.43 mm
Lobe height	46.67 mm (minimum)
Camshaft endplay	0.025 to 0.305 mm

Torque specifications*

	Nm
Main bearing cap bolts and studs	
Stage 1 in sequence (inner bolts)	20
Stage 2 in sequence (inner bolts)	Tighten an additional 80-degrees
Stage 1 in sequence (outer studs)	20
Stage 2 in sequence (outer studs)	Tighten an additional 53-degrees
Stage 3 in sequence (side bolts)	25
Connecting rod nuts	
Step 1	20
Step 2	Tighten an additional 75-degrees

** Refer to Chapter 2, Part D for additional torque specifications.*

1 General information

Included in this portion of Chapter 2 are the general overhaul procedures for the cylinder heads and internal engine components.

The information ranges from advice concerning preparation for an overhaul and the purchase of renewal parts to detailed, step-by-step procedures covering removal and refitting of internal engine components and the inspection of parts.

The following Sections have been written based on the assumption the engine has been removed from the vehicle. For information concerning in-vehicle engine repair, as well as removal and refitting of the external components necessary for the overhaul, see Part A, B, C or D of this Chapter.

The Specifications included in this Part are only those necessary for the inspection and overhaul procedures which follow. Refer to Part A or B for additional Specifications.

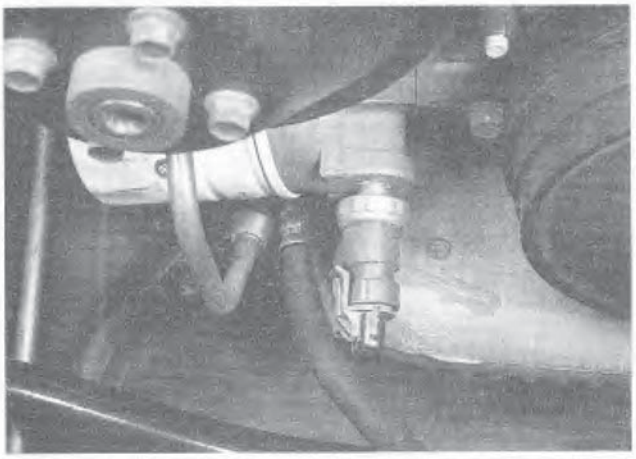
2 Engine overhaul - general information

Refer to illustrations 2.4a and 2.4b

It's not always easy to determine when, or if, an engine should be completely overhauled, as a number of factors must be considered.

The number of kilometres driven is not always an indication that an overhaul is needed, while a low amount of kilometres driven doesn't preclude the need for an overhaul. Frequency of servicing is probably the most important consideration. An engine that's had regular and frequent oil and filter changes, as well as other required maintenance, will most likely give many thousands of kilometres of reliable service. Conversely, a neglected engine may require an overhaul very early in its life.

Excessive oil consumption is an indication that piston rings, valve seals and/or valve guides are in need of attention. Make sure oil leaks aren't responsible before deciding the rings and/or guides are bad. Perform a cylinder compression check to determine the extent of the work required (see Section 3).



2.4a The oil pressure sensor is near the oil filter - V6 engines

2.4b Oil pressure sending unit location - 5.7 litre Gen III V8 engines

Remove the oil pressure sending unit and check the oil pressure with a gauge installed in its place. The sending unit is located near the oil filter (see illustrations). Compare the results to this Chapter's Specifications. As a general rule, engines should have 70 kPa oil pressure for every 1,000 rpm. If the pressure is extremely low, the bearings and/or oil pump are probably worn out.

Loss of power, rough running, knocking or metallic engine noises, excessive valvetrain noise and high fuel consumption rates may also point to the need for an overhaul, especially if they're all present at the same time. If a complete tune-up doesn't remedy the situation, major mechanical work is the only solution.

An engine overhaul involves restoring the internal parts to the specifications of a new engine. During an overhaul, the piston rings are renewed and the cylinder walls are reconditioned (rebored and/or honed). If a rebore is done by an automotive machine shop, new oversize pistons will also be fitted. The main bearings, connecting rod bearings and camshaft bearings are generally renewed with new ones and, if necessary, the crankshaft may be reground to restore the journals. Generally, the valves are serviced as well, since they're usually in less-than-perfect condition at this point. While the engine is being overhauled, other components, such as the starter and alternator, can be rebuilt as well. The end result should be a like-new engine that will give many trouble free kilometres.

> ***Note:*** *Critical cooling system components such as the hoses, drivebelts, thermostat and water pump MUST be renewed with new parts when an engine is overhauled. The radiator should be checked carefully to ensure it isn't clogged or leaking (see Chapter 3).*

Before beginning the engine overhaul, read through the entire procedure to familiarise yourself with the scope and requirements of the job. Overhauling an engine isn't particularly difficult, if you follow all of the instructions carefully, have the necessary tools and equipment and pay close attention to all specifications; however, it can be time consuming. Plan on the vehicle being tied up for a minimum of two weeks, especially if parts must be taken to an automotive machine shop for repair or reconditioning. Check on availability of parts and make sure any necessary special tools and equipment are obtained in advance. Most work can be done with typical hand tools, although a number of precision measuring tools are required for inspecting parts to determine if they must be renewed. Often an automotive machine shop will handle the inspection of parts and offer advice concerning reconditioning and renewal.

> ***Note:*** *Always wait until the engine has been completely disassembled and all components, especially the engine block, have been inspected before deciding what service and repair operations must be performed by an automotive machine shop. Since the block's condition will be the major factor to consider when determining whether to overhaul the original engine or buy a rebuilt one, never purchase parts or have machine work done on other components until the block has been thoroughly inspected. As a general rule, time is the primary cost of an overhaul, so it doesn't pay to fit worn or substandard parts.*

A freshly rebuilt engine generates more heat than a worn engine. This may overstress the cooling system. Since the radiator must be removed, it is good practice to send it to a radiator shop to be disassembled cleaned, inspected and rodded. If the old water pump is going to be reused, place it into a bucket of water during the rebuilding procedure. This will insure that the seals will not dry out and leak when it is refitted.

As a final note, to ensure maximum life and minimum trouble from a rebuilt engine, everything must be assembled with care in a spotlessly clean environment.

3 Cylinder compression check

1 A compression check will tell you what mechanical condition the upper end (pistons, rings, valves, head gaskets) of the engine is in. Specifically, it can tell you if the compression is down due to leakage caused by worn piston rings, defective valves and seats or a blown head gasket.

> ***Note:*** *The engine must be at normal operating temperature and the battery must be fully charged for this check.*

2 Begin by cleaning the area around the spark plugs before you remove them. Compressed air should be used, if available, otherwise a small brush or even a bicycle tyre pump will work. The idea is to prevent dirt from getting into the cylinders as the compression check is being done.

3 Remove all of the spark plugs from the engine (see Chapter 1).

4 Block the throttle wide open.

5 Remove the F25 fuse from the relay housing in the engine compartment.

Note: On 5.7 litre Gen III engines disconnect the primary electrical connectors at the coils.

6 Refit the compression gauge in the number one spark plug hole.

7 Crank the engine over at least seven compression strokes and watch the gauge. The compression should build up quickly in a healthy engine. Low compression on the first stroke, followed by gradually increasing pressure on successive strokes, indicates worn piston rings. A low compression reading on the first stroke, which doesn't build up during successive strokes, indicates leaking valves or a blown head gasket (a cracked head could also be the cause). Deposits on the undersides of the valve heads can also cause low compression. Record the highest gauge reading obtained.

8 Repeat the procedure for the remaining cylinders, turning the engine over for the same length of time for each cylinder, and compare the results to this Chapter's Specifications.

9 If the readings are below normal, add some engine oil (about three squirts from a plunger-type oil can) to each cylinder, through the spark plug hole, and repeat the test.

10 If the compression increases after the oil is added, the piston rings are definitely worn. If the compression doesn't increase significantly, the leakage is occurring at the valves or head gasket. Leakage past the valves may be caused by burned valve seats and/or faces or warped, cracked or bent valves.

11 If two adjacent cylinders have equally low compression, there's a strong possibility the head gasket between them is blown. The appearance of coolant in the combustion chambers or the crankcase would verify this condition.

12 If one cylinder is about 20-percent lower than the others, and the engine has a slightly rough idle, a worn exhaust lobe on the camshaft could be the cause.

13 If the compression is unusually high, the combustion chambers are probably coated with carbon deposits. If that's the case, the cylinder heads should be removed and decarbonised.

14 If compression is way down or varies greatly between cylinders, it would be a good idea to have a leak-down test performed by an automotive repair shop. This test will pinpoint exactly where the leakage is occurring and how severe it is.

15 Refit the fuses and drive the vehicle to restore the "block learn" memory.

4 Vacuum gauge diagnostic checks

A vacuum gauge provides valuable information about what is going on in the engine at a low cost. You can check for worn rings or cylinder walls, leaking head or inlet manifold gaskets, incorrect carburettor adjustments, restricted exhaust, stuck or burned valves, weak valve springs, improper ignition or valve timing and ignition problems.

Unfortunately, vacuum gauge readings are easy to misinterpret, so they should be used in conjunction with other tests to confirm the diagnosis.

Both the gauge readings and the rate of needle movement are important for accurate interpretation. Most gauges measure vacuum in kilopascals (kPa) or millimeters of mercury (mm-Hg). As vacuum increases (or atmospheric pressure decreases), the reading will increase. Also, for every 300 meter increase in elevation above sea level, the gauge readings will decrease about 25 mm of mercury.

Connect the vacuum gauge directly to inlet manifold vacuum, not to ported (carburettor) vacuum. Be sure no hoses are left disconnected during the test or false readings will result.

Before you begin the test, allow the engine to warm up completely. Block the wheels and set the parking brake. With the transmission in Park, start the engine and allow it to run at normal idle speed.

Read the vacuum gauge; an average, healthy engine should normally produce about 425 to 550 mm-Hg of vacuum with a fairly steady needle. Refer to the following vacuum gauge readings and what they indicate about the engine's condition:

1 A low, steady reading usually indicates a leaking gasket between the inlet manifold and carburettor or throttle body, a leaky vacuum hose, late ignition timing or incorrect camshaft timing. Eliminate all other possible causes, utilizing the tests provided in this Chapter before you remove the timing chain cover to check the timing marks.

2 If the reading is far below normal and it fluctuates at that low reading, suspect an inlet manifold gasket leak at an inlet port.

3 If the needle has regular drops of about 50 mm-Hg at a steady rate, the valves are probably leaking. Perform a compression or leak-down test to confirm this.

4 An irregular drop or down-flick of the needle can be caused by a sticking valve or an ignition misfire. Perform a compression or leak-down test and read the spark plugs.

5 A rapid vibration of about 25 mm-Hg at idle combined with exhaust smoke indicates worn valve guides. Perform a leak-down test to confirm this. If the rapid vibration occurs with an increase in engine speed, check for a leaking inlet manifold gasket or head gasket, weak valve springs, burned valves or ignition misfire.

6 A slight fluctuation, say 20 millimeters up and down, may mean ignition problems. Check all the usual tune-up items and, if necessary, run the engine on an ignition analyzer.

7 If there is a large fluctuation, perform a compression or leak-down test to look for a weak or dead cylinder or a blown head gasket.

8 If the needle moves slowly through a wide range, check for a clogged PCV system, incorrect idle fuel mixture, throttle body or inlet manifold gasket leaks.

9 Check for a slow return after revving the engine by quickly snapping the throttle open until the engine reaches about 2,500 rpm and let it shut. Normally the reading should drop to near zero, rise above normal idle reading (about 100 mm-Hg over) and then return to the previous idle reading. If the vacuum returns slowly and doesn't peak when the throttle is snapped shut, the rings may be worn. If there is a long delay, look for a restricted exhaust system (often the muffler or catalytic converter). An easy way to check this is to temporarily disconnect the exhaust ahead of the suspected part and re-test.

5 Engine removal - methods and precautions

If you've decided the engine must be removed for overhaul or major repair work, several preliminary steps should be taken. Locating a suitable place to work is extremely important. Adequate work space, along with storage space for the vehicle, will be needed.

Cleaning the engine compartment and engine before beginning the removal procedure will help keep tools clean and organised. An engine hoist will also be necessary. Safety is of primary importance, considering the potential hazards involved in removing the engine from this vehicle.

If the engine is being removed by a novice, a helper should be available. Advice and aid from someone more experienced would also be helpful. There are many instances when one person cannot simultaneously perform all of the operations required when lifting the engine out of the vehicle.

Plan the operation ahead of time. Arrange for or obtain all of the tools and equipment you'll need prior to beginning the job. Some of the equipment necessary to perform engine removal and refitting safely and with relative ease in addition to a hydraulic jack, jack stands and an engine hoist) are a complete sets of spanners and sockets as described in the front of this manual, wooden blocks and plenty of rags and cleaning solvent for mopping up spilled oil, coolant and petrol.

Plan for the vehicle to be out of use for quite a while. A machine shop will be required to perform some of the work which the do-it-yourselfer can't accomplish without special equipment. These shops often have a busy schedule, so it would be a good idea to consult them before removing the engine in order to accurately estimate the amount of time required to rebuild or repair components that may need work.

Always be extremely careful when removing and refitting the engine. Serious injury can result from careless actions. Plan ahead, take your time and a job of this nature, although major, can be accomplished successfully.

Note: *Because it may be some time before you refit the engine, it is very helpful to make sketches or take photos of various accessory mountings and wiring hookups before removing the engine.*

6 Engine - removal and refitting

Warning 1: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first. When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

Warning 2: *The air conditioning system is under high pressure - have a dealer service department or service station evacuate the system and recapture the refrigerant before disconnecting any of the hoses or fittings.*

Note: *The factory preferred method of engine removal is to remove the engine with the transmission attached to it. The transmission can be left in the vehicle, if you prefer. Make sure to mark the flexplate/torque converter if you choose to leave the transmission in place. Refer to Chapter 7 for more information on separating the engine and the transmission.*

REMOVAL

Refer to illustrations 6.5, 6.13 and 6.17

1 Relieve the fuel system pressure (see Chapter 4), then disconnect the negative cable from the battery.

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. See the owner's manual for this procedure.*

2 Mark the hood hinges with a felt pen and remove the hood. Refer to Chapter 11.

3 Cover the fenders and cowl. Special pads are available to protect the fenders, but an old bedspread or blanket will also work. Remove the hood (see Chapter 11).

4 Remove the air inlet duct assembly (see Chapter 4).

5 To ensure correct reassembly, label each vacuum line, emission system hose, electrical connector, ground strap and fuel line. Pieces of masking tape with numbers or letters written on them prevent confusion at assembly time (see illustration), or sketch the engine compartment routing of lines, hoses and wires. Disconnect each fitting as you label them.

6 Drain the cooling system (see Chapter 1) and label and detach all coolant hoses from the engine.

7 Disconnect the throttle and cruise control cables (see Chapter 4).

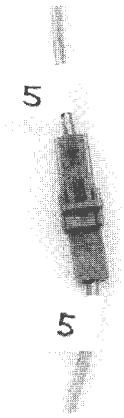
8 Disconnect the air conditioning hoses from the compressor, hang them out of the way, detach the air conditioning compressor from its mounting bracket and remove it from the engine compartment (see Chapter 3).

9 Raise the vehicle and suitably support it on jackstands. While raised, perform the disassembly procedures that can be done only from underneath, such as disconnecting the exhaust, and disconnecting the transmission cooler lines where they are held by a clip to one of the sump bolts (automatic transmission models) and disconnecting wiring harnesses attached to the block and the transmission.

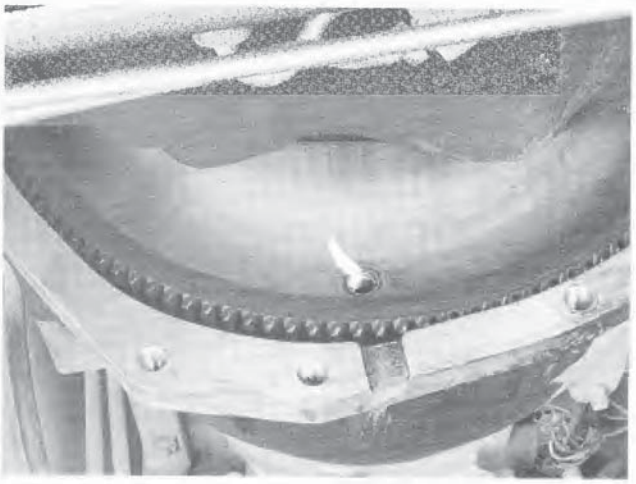
10 Drain the engine oil and remove the filter (see Chapter 1). Drain the transmission if you are removing it along with the engine.

11 Remove the left side kick panel, the glove box and the panels necessary to get access to the ECM wiring harnesses.

Note: *On 5.7 litre V8 and VZ models, disconnect the wiring from the ECM and remove the ECM from the engine compartment.*



6.5 Label each wire before unplugging the connector



6.13 Paint or scribe alignment marks on the driveplate and the torque converter to ensure that the two components are still in balance when they're reassembled

12 Disconnect all the wiring harnesses that run from the ECM to the engine. Pull the harnesses out into the engine compartment and disconnect them where they are tied to the fender.

13 If you are removing the engine without the transmission on an automatic transmission vehicle, mark the driveplate to the torque converter (see illustration).

14 Remove the rear transmission crossmember after disconnecting the transmission wiring. Support the rear of the transmission with a floor jack. Remove the driveshaft. Refer to Chapter 8.

15 Remove the radiator (see Chapter 3).

16 Unbolt the power steering pump and bracket and tie them out of the way.

17 Attach an engine sling or a length of chain to the lifting brackets on the engine (see illustration). Raise the engine enough to take the weight off the engine mounts and remove the engine mount through-bolts.

18 Raise the engine and pull it forward. There are several fragile components on this particular vehicle which can be easily damaged in removing the engine. Pay close attention to the transmission electrical pass-through connector and the various ground wires and harnesses.

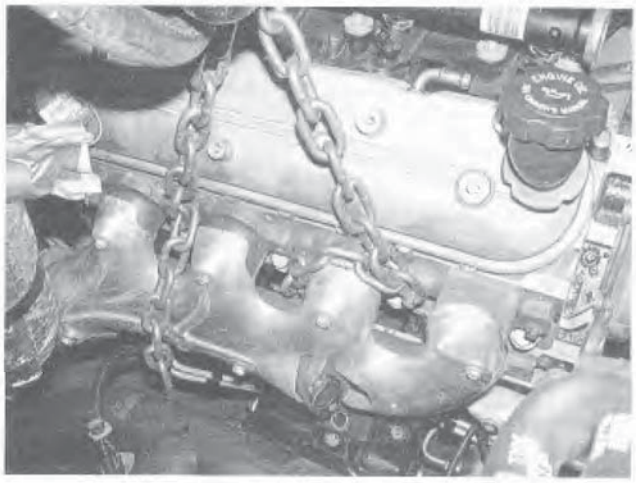
19 Tie the wiring harnesses out of the way, raise the engine with the hoist, and with a combination of tilting, twisting and raising, move the engine around any obstructions and pull it out of the vehicle, raising it high enough to clear the front of the body.

20 Remove the transmission flexplate or flywheel (see Section 28) and mount the engine on an engine stand.

REFITTING

21 While the engine is out, check the engine mounts and the transmission mount (see Chapter 7). If they're worn or damaged, renew them.

22 Carefully lower the engine, twisting it to clear any harnesses or obstructions. If you left the transmission in place, work until the transmission input shaft or converter snout lines up and the bellhousing-to-engine bolts can be inserted.



6.17 Attach a sling or chain to the lifting brackets and remove the engine - a second chain can be mounted to the cylinder head to help steady the engine during removal

Caution: *DO NOT use the transmission-to-engine bolts to force the transmission and engine together. Take great care when mating the torque converter to the driveplate, following the procedure outlined in Chapter 7, Part B. Make sure the alignment marks you made on the driveplate and the torque converter during removal are lined up.*

23 On models with an automatic transmission, refit the driveplate-to-torque converter bolts and tighten them to the torque listed in this Chapter's Specifications.

24 Refit the remaining components in the reverse order of removal. Double-check to make sure everything is hooked up right, using the sketches or photos taken earlier to go by.

25 Add coolant, oil, power steering and transmission fluid as needed.

26 Run the engine and check for leaks and proper operation of all accessories, then refit the hood and test drive the vehicle.

7 Engine rebuilding alternatives

The home mechanic is faced with a number of options when performing an engine overhaul. The decision to renew the engine block, piston/connecting rod assemblies and crankshaft depends on a number of factors, with the number one consideration being the condition of the block. Other considerations are cost, access to machine shop facilities, parts availability, time required to complete the project and the extent of prior mechanical experience.

Some of the rebuilding alternatives include:

Individual parts - If the inspection procedures reveal the engine block and most engine components are in reusable condition, purchasing individual parts may be the most economical alternative. The block, crankshaft and piston/connecting rod assemblies should all be inspected carefully. Even if the block shows little wear, the cylinder bores should be surface-honed.

Short-block - A short-block consists of an engine block with a crankshaft and piston/connecting rod assemblies already refitted. All new bearings are incorporated and all clearances will be correct. The existing camshaft, valve train components, cylinder heads and external parts can be bolted to the short block with little or no machine shop work necessary. Some

rebuilding companies include a new timing chain, camshaft and lifters with their short-block assemblies.

Long-block - A long-block consists of a short block plus an oil pump, sump, cylinder heads, rocker arm covers, camshaft and valve train components, timing sprockets and chain and timing chain cover. All components are fitted with new bearings, seals and gaskets incorporated throughout. The refitting of manifolds and external parts is all that's necessary. Give careful thought to which alternative is best for you and discuss the situation with local automotive machine shops, auto parts dealers and experienced rebuilders before ordering or purchasing renewal parts.

8 Engine overhaul - disassembly sequence

1 It's much easier to disassemble and work on the engine if it's mounted on a portable engine stand. A stand can often be rented quite cheaply from an equipment rental yard. Before it's mounted on a stand, the flywheel/driveplate should be removed from the engine.

2 If a stand isn't available, it's possible to disassemble the engine with it blocked up on the floor. Be extra careful not to tip or drop the engine when working without a stand.

3 If you're going to obtain a rebuilt engine, all external components must come off first, to be transferred to the new engine, just as they will if you're doing a complete engine overhaul yourself. These include:

Alternator and brackets
Emissions control components
Ignition coil/module assembly (V6 models), distributor (V8 models), spark plug wires and spark plugs
Thermostat and housing
Water pump
Engine front cover
Fuel injection components
Inlet/exhaust manifolds
Oil filter
Engine mounts
Flywheel/driveplate
Rear main oil seal housing (V6 models)

Note: *When removing the external components from the engine, pay close attention to details that may be helpful or important during refitting. Note the refitted position of gaskets, seals, spacers, pins, brackets, washers, bolts and other small items.*

4 If you're obtaining a short-block, then the cylinder heads, sump and oil pump will have to be removed as well. See Engine rebuilding alternatives for additional information regarding the different possibilities to be considered.

5 If you're planning a complete overhaul, the engine must be disassembled and the internal components removed in the following general order:

Inlet and exhaust manifolds
Valve covers
Rocker arm assemblies and pushrods
Valve lifters
Cylinder heads
Timing chain cover
Oil pump
Timing chain and sprockets
Camshaft
Balance shaft (V6 models)
Sump
Piston/connecting rod assemblies
Crankshaft and main bearings

6 Before beginning the disassembly and overhaul procedures, make sure the following items are available. Also, refer to Engine overhaul - reassembly sequence for a list of tools and materials needed for engine reassembly.

Common hand tools
Small cardboard boxes or plastic bags for storing parts
Gasket scraper
Ridge reamer
Engine balancer puller
Micrometers
Telescoping gauges
Dial indicator set
Valve spring compressor
Cylinder surfacing hone
Piston ring groove-cleaning tool
Electric drill motor
Tap and die set
Wire brushes
Oil gallery brushes
Cleaning solvent

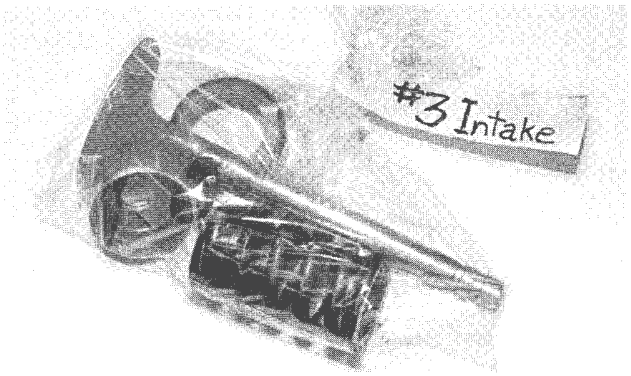
9 Cylinder head - disassembly

Refer to illustrations 9.2, 9.3 and 9.4

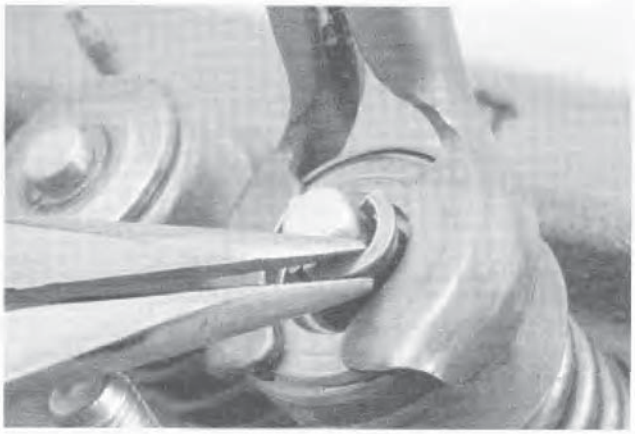
Note: *New and rebuilt cylinder heads are commonly available for most engines at dealerships and auto parts stores. Due to the fact that some specialised tools are necessary for the disassembly and inspection procedures, and renewal parts aren't always readily available, it may be more practical and economical for the home mechanic to purchase renewal heads rather than taking the time to disassemble, inspect and recondition the originals.*

1 Cylinder head disassembly involves removal of the inlet and exhaust valves and related components. Remove the rocker arm bolts, pivots and rocker arms from the cylinder heads. Label the parts or store them separately so they can be refitted in their original locations. Discard the rocker pivot bolts.

2 Before the valves are removed, arrange to label and store them, along with their related components, so they can be kept separate and refitted in their original locations (see illustration).



9.2 A small plastic bag, with an appropriate label, can be used to store the valve train components so they can be kept together and refitted in the original positions



9.3 Use a valve spring compressor to compress the spring, then remove the keepers from the valve stem

9.4 If the valve won't pull through the guide, deburr the edge of the stem end and the area around the top of the keeper groove with a file or whetstone

3 Compress the springs on the first valve with a spring compressor and remove the keepers (see illustration). Carefully release the valve spring compressor and remove the retainer, the spring and the spring seat (if used). Use a small screwdriver to remove the O-ring seal from the top of the valve stem on V8 models.

4 Pull the valve out of the head, then remove the oil seal from the guide on V6 models. If the valve binds in the guide (won't pull through), push it back into the head and deburr the area around the keeper groove with a fine file or whetstone (see illustration).

5 Repeat the procedure for the remaining valves. Remember to keep all the parts for each valve together so they can be refitted in the same locations.

6 Once the valves and related components have been removed and stored in an organised manner, the heads should be thoroughly cleaned and inspected. If a complete engine overhaul is being done, finish the engine disassembly procedures before beginning the cylinder head cleaning and inspection process.

10 Cylinder head - cleaning and inspection

1 Thorough cleaning of the cylinder heads and related valve train components, followed by a detailed inspection, will enable you to decide how much valve service work must be done during the engine overhaul.

Note: *If the engine was severely overheated, the cylinder head is probably warped (see Step 12).*

CLEANING

2 Scrape all traces of old gasket material and sealant off the head gasket, inlet manifold and exhaust manifold mating surfaces. Be very careful not to gouge the cylinder head. Special gasket removal solvents that soften gaskets and make removal much easier are available at auto parts stores.

3 Remove all built-up scale from the coolant passages.

4 Run a stiff wire brush through the various holes to remove deposits that may have formed in them.

5 Run an appropriate-size tap into each of the threaded holes to remove corrosion and thread sealant that may be present. If compressed air is available, use it to clear the holes of debris produced by this operation.

Warning: *Wear eye protection when using compressed air!*

6 Clean the rocker arm pivot stud or bolt threads with a wire brush.

7 Clean the cylinder head with solvent and dry it thoroughly. Compressed air will speed the drying process and ensure that all holes and recessed areas are clean.

Note: *Decarbonizing chemicals are available and may prove very useful when cleaning cylinder heads and valve train components. They're very caustic and should be used with caution. Be sure to follow the instructions on the container.*

8 Clean the rocker arms, pivots, bolts and pushrods with solvent and dry them thoroughly (don't mix them up during the cleaning process). Compressed air will speed the drying process and can be used to clean out the oil passages.

9 Clean all the valve springs, keepers and retainers with solvent and dry them thoroughly. Do the components from one valve at a time to avoid mixing up the parts.

10 Scrape off any heavy deposits that may have formed on the valves, then use a motorised wire brush to remove deposits from the valve heads and stems. Again, make sure the valves don't get mixed up.

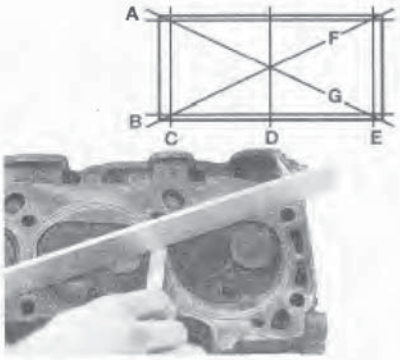
INSPECTION

Note: *Be sure to perform all of the following inspection procedures before concluding machine shop work is required. Make a list of the items that need attention.*

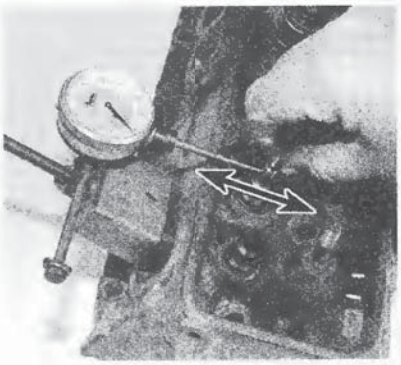
Cylinder head

Refer to illustrations 10.12 and 10.13

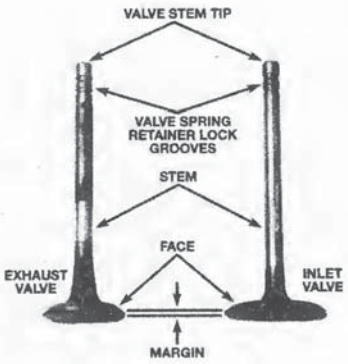
11 Inspect the head very carefully for cracks, evidence of coolant leakage and other damage. If cracks are found, check with an automotive machine shop concerning repair. If repair isn't possible, a new cylinder head must be obtained.



10.12 Check the cylinder head gasket surface for warpage by trying to slip a feeler gauge under the straightedge (see this Chapter's Specifications for the maximum warpage allowed and use a feeler gauge of that thickness)



10.13 A dial indicator can be used to determine the valve stem-to-guide clearance (move the valve stem as indicated by the arrows)



10.15 Check for valve wear at the points shown here

12 Using a precision machinist's straightedge and feeler gauge, check the head gasket mating surface for warpage (see illustration). If the warpage exceeds the limit in this Chapter's Specifications, it can usually be resurfaced at an automotive machine shop.

> ***Note:*** *If the heads are resurfaced, the inlet manifold flanges may also require machining.*

13 Examine the valve seats in each of the combustion chambers. If they're pitted, cracked or burned, the head will require valve service that's beyond the scope of the home mechanic. Check the valve stem-to-guide clearance by measuring the lateral movement of the valve stem with a dial indicator attached securely to the head (see illustration). The valve must be in the guide and approximately 1 mm off the seat. The total valve stem movement indicated by the gauge needle must be divided by two to obtain the actual clearance. After this is done, if there's still some doubt regarding the condition of the valve guides, they should be checked by an automotive machine shop (the cost should be minimal).

14 Check the thicknesses of the heads to see if there is sufficient material to allow surfacing. Measure from the head lower surface to the provided pads with a depth micrometer on V6 engines and compare your readings to the figure in the Specifications in this Chapter. There are machined pads near the exhaust ports on V8 engines. Use a micrometer or dial caliper to measure from these pads to the head surface.

Valves

Refer to illustrations 10.15 and 10.16

15 Carefully inspect each valve face for uneven wear, deformation, cracks, pits and burned areas. Check the valve stem for scuffing and galling and the neck for cracks. Rotate the valve and check for any obvious indication that it's bent. Look for pits and excessive wear on the end of the stem. The presence of any of these conditions (see illustration) indicates the need for valve service by an automotive machine shop.

16 Measure the margin width on each valve (see illustration). Any valve with a margin narrower than specified in this Chapter will have to be renewed with a new one.

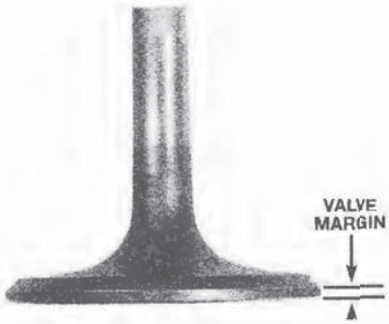
Valve components

Refer to illustrations 10.17 and 10.18

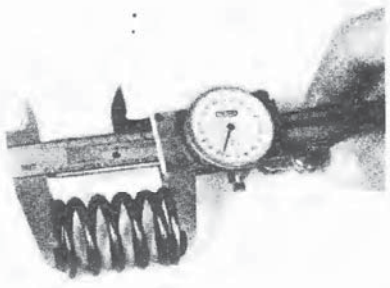
17 Check each valve spring for wear (on the ends) and pits. The tension of all springs should be checked with a special fixture before deciding they're suitable for use in a rebuilt engine (see illustration) (take the springs to an automotive machine shop for this check).

18 Stand each spring on a flat surface and check it for squareness (see illustration). If any of the springs are distorted or sagged, renew all of them.

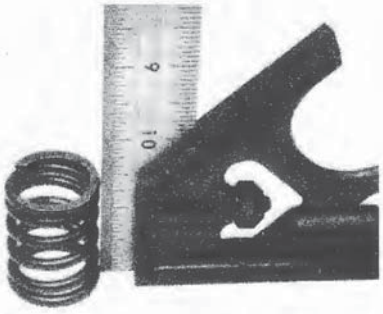
19 Check the spring retainers and keepers for obvious wear and cracks. Any questionable parts should be renewed with



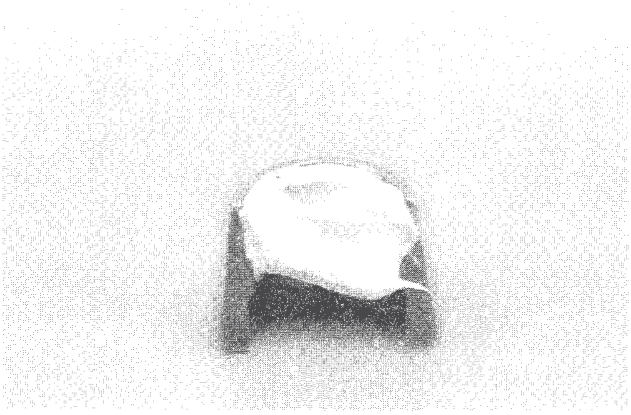
10.16 The margin width on the valve must be as specified (if no margin exists, the valve cannot be re-used)



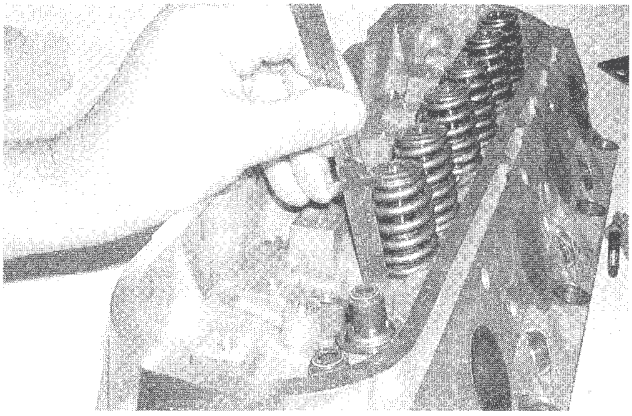
10.17 Measure the free length of each valve spring with a dial or vernier caliper



10.18 Check each valve spring for squareness



12.6 Apply a small dab of grease to each keeper as shown here before refitting - it'll hold them in place on the valve stem as the spring is released



12.8 Be sure to check the valve spring installed height (the distance from the top of the seat/shims to the top of the shield or the bottom of the retainer)

new ones, as extensive damage will occur if they fail during engine operation.

Rocker arm components

20 Check the rocker arm faces (the areas that contact the pushrod ends and valve stems) for pits, wear, galling, score marks and rough spots. Check the rocker arm pivot contact areas and pivots as well. Look for cracks in each rocker arm and bolt. New pivot bolts must be used on V8 models.

21 Inspect the pushrod ends for scuffing and excessive wear. Roll each pushrod on a flat surface, like a piece of plate glass, to determine if it's bent. Check the pushrod guide plates for signs of excessive wear.

22 Check the rocker arm bolt holes or studs in the cylinder heads for damaged threads.

23 Any damaged or excessively worn parts must be renewed with new ones.

All components

24 If the inspection process indicates the valve components are in generally poor condition and worn beyond the limits specified, which is usually the case in an engine that's being overhauled, reassemble the valves in the cylinder head (see Section 11 for valve servicing recommendations).

11 Valves - servicing

1 Because of the complex nature of the job and the special tools and equipment needed, servicing of the valves, the valve seats and the valve guides, commonly known as a valve job, should be done by a professional.

2 The home mechanic can remove and disassemble the head, do the initial cleaning and inspection, then reassemble and deliver it to a dealer service department or an automotive machine shop for the actual service work. Doing the inspection will enable you to see what condition the head and valvetrain components are in and will ensure that you know what work and new parts are required when dealing with an automotive machine shop.

3 The dealer service department, or automotive machine shop, will remove the valves and springs, recondition or renew the valves and valve seats, recondition the valve guides, check and renew the valve springs, rotators, spring retainers and keepers (as necessary), renew the valve seals, reassemble the valve components and make sure the refitted spring height is correct. The cylinder head gasket surface will also be resurfaced if it's warped.

4 After the valve job has been performed by a professional, the head will be in like new condition. When the head is returned, be sure to clean it again before refitting on the engine to remove any metal particles and abrasive grit that may still be present from the valve service or head resurfacing operations. Use compressed air, if available, to blow out all the oil holes and passages.

12 Cylinder head - reassembly

Refer to illustrations 12.6 and 12.8

1 Regardless of whether or not the head was sent to an automotive repair shop for valve servicing, make sure it's clean before beginning reassembly.

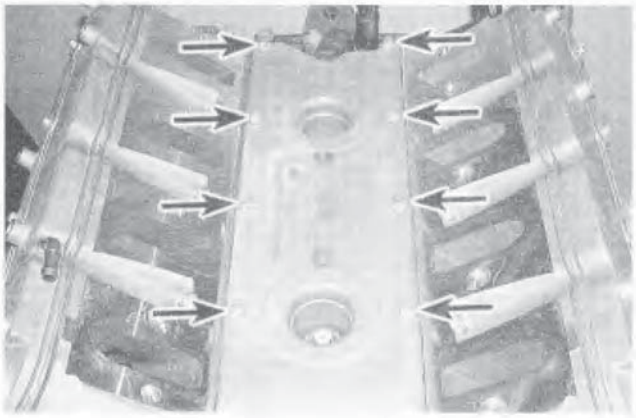
2 If the head was sent out for valve servicing, the valves and related components will already be in place. Begin the reassembly procedure with Step 8.

3 Beginning at one end of the head, lubricate and refit the first valve. Apply moly-base grease or clean engine oil to the valve stem.

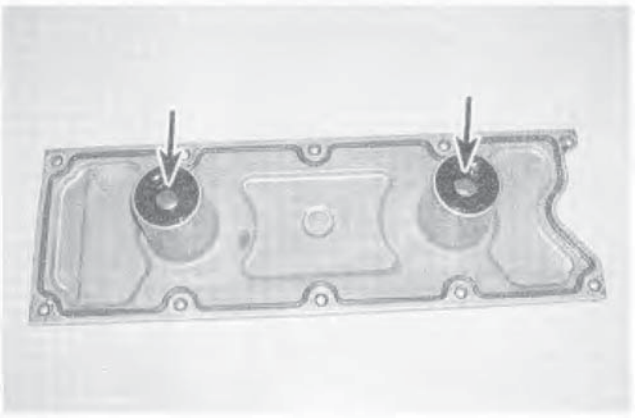
4 Refit the shims, if originally refitted, before the valve seals on V6 models.

5 Fit new seals on each of the valve guides on V6 models. Gently tap each seal into place until it's completely seated on the guide. Many seal sets come with a plastic installer, but use only hand force. Do not hammer on the seals or they could be driven down too far and subsequently leak. Don't twist or cock the seals during refitting or they won't seal properly on the valve stems.

6 On V8 models, fit new O-ring valve seals in the lower stem grooves of the valves. Compress the springs with a valve spring compressor and carefully fit the retainers. Fit the keepers in the groove, then slowly release the compressor and make very sure the keepers seat properly. Apply a small dab of grease to each keeper to hold it in place if necessary (see illustration). Tap the valve stem tips with a plastic hammer to seat the keepers, if necessary.



13.1a Valley cover mounting bolts - 5.7 litre Gen III V8 engine



13.1b Be sure to renew the valley cover gasket and the knock sensor oil seals (arrows) upon refitting

7 Repeat the procedure for the remaining valves. Be sure to return the components to their original locations - don't mix them up!

8 Check the refitted valve spring height with a machinist's rule or a dial caliper (see illustration). If the head was sent out for service work, the refitted height should be correct (but don't automatically assume it is). The measurement is taken from the top of each spring seat or top shim to the bottom of the retainer. If the height is greater than specified in this Chapter, shims can be added under the springs to correct it.

> ***Caution:*** *Do not, under any circumstances, shim the springs to the point where the refitted height is less than specified.*

9 Apply moly-base grease to the rocker arm faces and the pivots, then refit the rocker arms and pivots on the cylinder heads. Tighten the bolts/nuts finger-tight.

13 Camshaft, balance shaft and bearings - removal and inspection

REMOVAL

Refer to illustrations 13.1a and 13.1b

1 Refer to Chapter 2A and 2B (V6 engines) or 2C or 2D (V8 engines) for the camshaft and lifter removal procedure. Disregard the Steps that do not apply, since the engine is already removed from the vehicle. On 5.7 litre Gen III V8 engines it will be necessary to remove the engine valley cover. Remove the bolts and detach the cover from the engine block. Be sure to install a new gasket and knock sensor oil seals upon installation (see illustrations). It is assumed that the cylinder heads and the coolant vapor vent tube are already removed at this point.

INSPECTION

Camshaft lobe lift check

Refer to illustrations 13.3 and 13.9

2 The first and easiest method to check camshaft lobe lift is through the use of a dial indicator with the camshaft fitted in the engine block and the rocker arms and spark plugs removed.

> ***Note:*** *The following method can also be used if the cylinder heads and/or pushrods have been removed by simply mounting the dial indicator on the deck surface of the engine block and placing the plunger against the top surface of the lifter on the cylinder you're checking.*

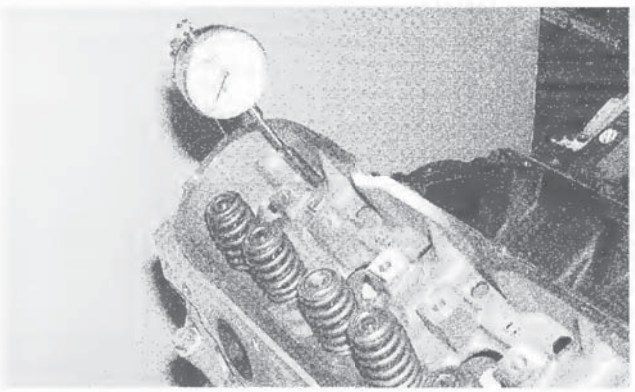
3 Beginning with the number one cylinder, mount a dial indicator on the engine and position the plunger against the top surface of the pushrod or lifter. Position the number one cylinder at TDC on the compression stroke. See Section 3, in Chapter 2A and 2B (V6 engines) or 2C or 2D (V8 engines). The plunger should be directly above and in line with the pushrod (see illustration).

4 Zero the dial indicator, then very slowly turn the crankshaft in the normal direction of rotation (clockwise) until the indicator needle stops and begins to move in the opposite direction. The point at which it stops indicates maximum cam lobe lift.

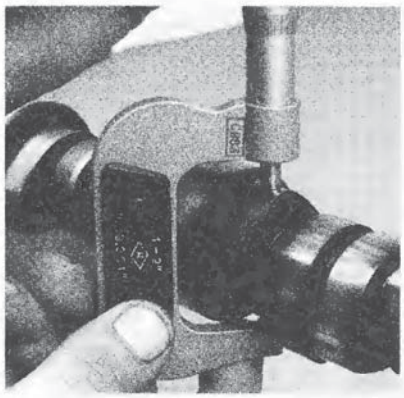
5 Record this figure for future reference, then reposition the piston at TDC on the compression stroke again.

6 Move the dial indicator to the other number one cylinder pushrod or lifter and repeat the check. Be sure to record the results for each valve.

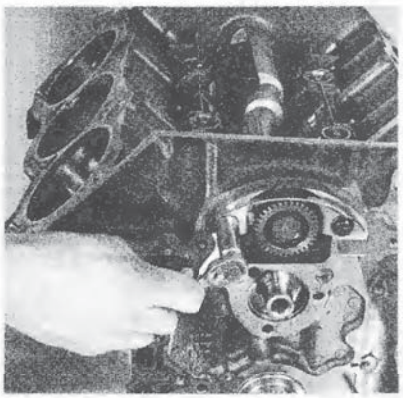
7 Repeat the check for the remaining valves. Since each piston must be at TDC on the compression stroke for this procedure, work from cylinder-to-cylinder following the firing order sequence.



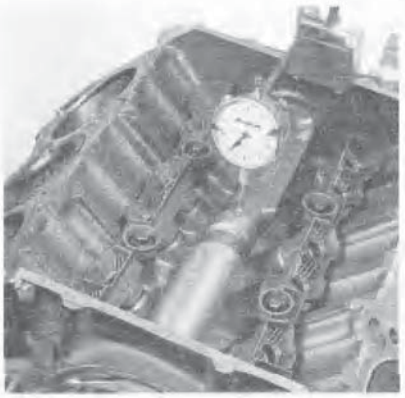
13.3 Checking camshaft lobe lift with the camshaft in the engine - always make sure the dial indicator plunger is directly in-line with the pushrod or lifter



13.9 To verify camshaft lobe lift, measure the major and the minor diameters - subtract each minor diameter from the major diameter to arrive at the lobe lift



13.18 Remove the balance shaft retainer



13.24 Measure the runout of the balance shaft at its centre

8 The second method for measuring camshaft lobe lift is obtained through the use of a micrometer with the camshaft removed from the engine block.

9 Using this method, measure the camshaft lobe height and the base circle (see illustration). The difference between the two measurements is the lobe lift (lobe height - base circle = lobe lift). Record this figure for future reference and repeat the check on the remaining camshaft lobes.

10 After the lobe lift check is complete, compare the results to the Specifications listed in Chapter 2A and 2B (V6 engines) or 2C or 2D (V8 engines). If the lobe lift is 0.01 mm less than specified, cam lobe wear has occurred and a new camshaft should be fitted.

Bearing journals, lobes and bearings

11 After the camshaft has been removed from the engine, cleaned with solvent and dried, inspect the bearing journals for uneven wear, pitting and evidence of seizure. If the journals are damaged, the bearing inserts in the block are probably damaged as well. Both the camshaft and bearings will have to be replaced.

> **Note:** *Camshaft bearing replacement requires special tools and expertise that place it beyond the scope of the average home mechanic. The tools for bearing removal and installation are available at stores that carry automotive tools, possibly even found at a tool rental business. It is advisable though, if the bearings are bad and the procedure is beyond your ability, take the engine block to an automotive machine shop to ensure that the job is done correctly.*

12 Measure the bearing journals with a micrometer to determine if they are excessively worn or out-of-round.

13 Check the camshaft lobes for heat discolouration, score marks, chipped areas, pitting and uneven wear. If the lobes are in good condition and if the lobe lift measurements recorded earlier are as specified, the camshaft can be reused.

Lifters

14 Clean the lifters with solvent and dry them thoroughly without mixing them up. Check each lifter wall and pushrod seat and for score marks and uneven wear. If the lifter walls are damaged or worn (which is not very likely), inspect the lifter bores in the engine block as well. If the pushrod seats are worn, check the pushrod ends.

15 Check the rollers carefully for wear and damage and make sure they turn freely without excessive play.

16 Used roller lifters can not be reinstalled with a new camshaft, but the original camshaft can be used if new lifters are installed. Always use new lifters when installing a new camshaft.

BALANCE SHAFT INSPECTION AND REMOVAL (V6 MODELS)

Refer to illustrations 13.18, 13.24 and 13.26

17 Refer to Chapter 2A and remove the balance shaft drive gear from the camshaft.

18 Remove one of the camshaft thrust plate bolts from behind the gear (see illustration).

19 Renew the balance shaft drive gear onto the camshaft, lining up one of its holes with the hole of the bolt you just removed.

20 Insert a 6-mm coarse pitch bolt through the gear and into the hole. This will lock the gear in position.

21 Refit the bolt onto the camshaft gear, using a 12 mm thick spacer under the bolt head.

22 Remove the balance shaft driven gear bolt.

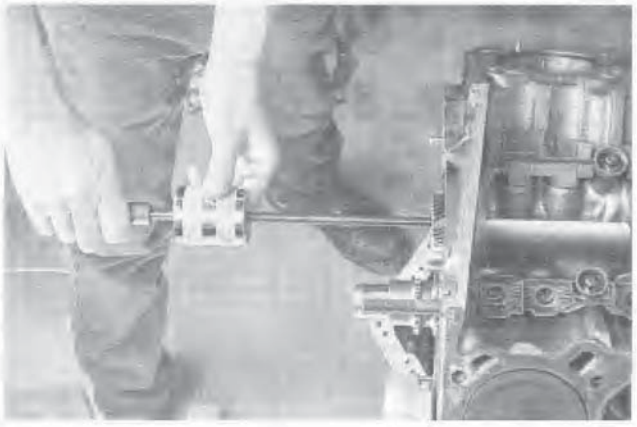
23 Continue to disassemble the components.

24 Using a dial indicator against the centre of the balance shaft, within the lifter valley of the block, measure the radial runout of the balance shaft and compare the figures to this Chapter's Specifications (see illustration). The balance shaft rides in a bearing at the front of the block and a bushing at the rear. If the runout exceeds Specifications, renew the balance shaft, bearing and bushing as a set. Check the balance shaft endplay, runout and backlash and compare the figures to this Chapter's Specifications.

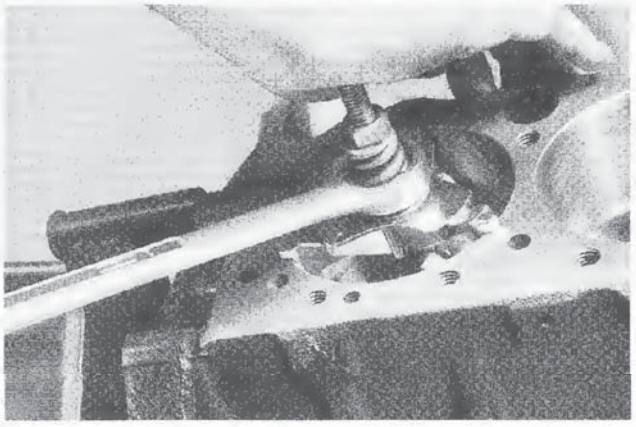
25 The rear bushing must be refitted by a machine shop with the proper tools, to the proper depth and with the oil hole lined up.

26 Remove the two bolts and the balance shaft retainer at the front of the block. The balance shaft's front bearing fits tightly into the block, and a slide hammer must be threaded into the front of the balance shaft to pull it out (see illustration).

27 Balance shaft and camshaft bearing renewal requires special tools and expertise that place it outside the scope of the home mechanic. Take the block to an automotive machine shop to ensure the job is done correctly.



13.26 A slide hammer must be threaded into the front of the balance shaft to pull the balance shaft front bearing out of the block



14.1 A ridge reamer is required to remove the ridge from the top of each cylinder - do this before removing the pistons!

14 Pistons and connecting rods - removal

Refer to illustrations 14.1, 14.3, 14.4 and 14.6

> ***Note:*** *Prior to removing the piston/connecting rod assemblies, remove the cylinder heads, the sump and the oil pump by referring to the appropriate Parts of Chapter 2.*

1 Use your fingernail to feel if a large ridge has formed at the upper limit of ring travel (about 5 mm down from the top of each cylinder). If carbon deposits or cylinder wear have produced large ridges, they must be completely removed with a special tool (see illustration). Follow the manufacturer's instructions provided with the tool. Failure to remove the ridges before attempting to remove the piston/connecting rod assemblies may result in piston breakage.

2 After the cylinder ridges have been removed, turn the engine upside-down so the crankshaft is facing up.

3 Before the connecting rods are removed, check the endplay with feeler gauges. Slide them between the first connecting rod and the crankshaft throw until the play is removed (see illustration). The endplay is equal to the thickness of the feeler gauge(s). If the endplay exceeds the service limit, new connecting rods may be required. If new rods (or a new crankshaft) are fitted, the endplay may fall under the minimum specified in this Chapter (if it does, the rods will have to be machined to restore it - consult an automotive machine shop for advice if necessary). Repeat the procedure for the remaining connecting rods.

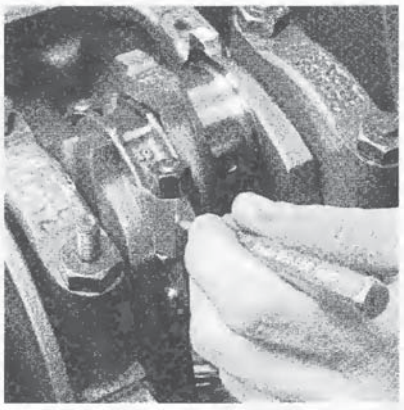
4 Check the connecting rods and caps for identification marks. If they aren't plainly marked, use a small centre-punch (see illustration) to make the appropriate number of indentations on each rod and cap (1, 2, 3, etc., depending on the cylinder they're associated with).

5 Loosen each of the connecting rod cap nuts 1/2-turn at a time until they can be removed by hand. Remove the number one connecting rod cap and bearing insert. Don't drop the bearing insert out of the cap.

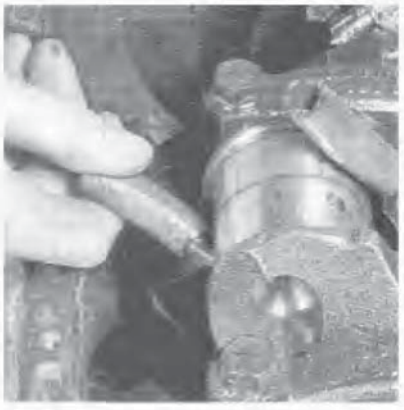
6 Slip a short length of plastic or rubber hose over each connecting rod cap bolt to protect the crankshaft journal and cylinder wall as the piston is removed (see illustration).

7 Remove the bearing insert and push the connecting rod/piston assembly out through the top of the engine. Use a

14.3 Check the connecting rod side clearance with a feeler gauge as shown

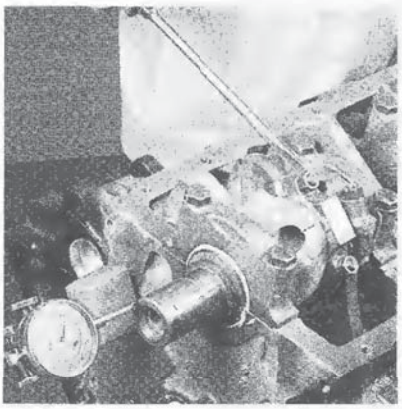


14.4 Mark the rod bearing caps in order from the front of the engine to the rear (one mark for the front cap, two for the second one and so on)



14.6 To prevent damage to the crankshaft journals and cylinder walls, slip sections of rubber or plastic hose over the rod bolts before removing the pistons/rods

15.1a Rear main oil seal retainer mounting bolts - 5.7 litre Gen III V8 engine shown



15.1b Prise the crankshaft fore and aft with the dial indicator reading the front of the crank. The needle deflection is the amount of endplay

15.3 Checking crankshaft endplay with a feeler gauge

wooden or plastic hammer handle to push on the upper bearing surface in the connecting rod. If resistance is felt, double-check to make sure all of the ridge was removed from the cylinder.

8 Repeat the procedure for the remaining cylinders.

9 After removal, reassemble the connecting rod caps and bearing inserts in their respective connecting rods and refit the cap nuts finger tight. Leaving the old bearing inserts in place until reassembly will help prevent the connecting rod bearing surfaces from being accidentally nicked or gouged.

10 Don't separate the pistons from the connecting rods.

15 Crankshaft - removal

Refer to illustrations 15.1a, 15.1b, 15.3, 15.4a and 15.4b

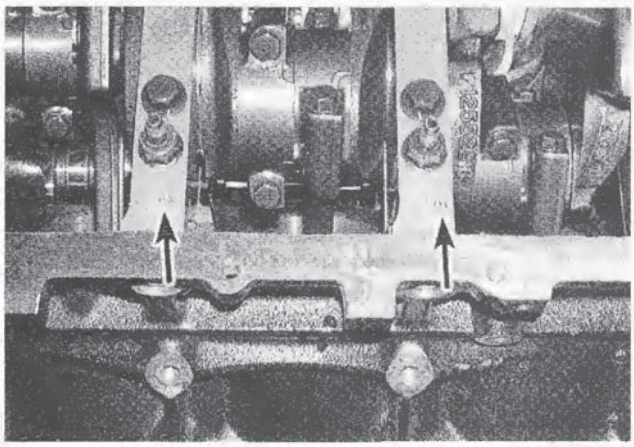
Note: *The crankshaft should be removed only after the engine has been removed from the vehicle. It's assumed the flywheel/driveplate, crankshaft balancer, timing chain, sump, oil pump and piston/connecting rod assemblies have already been removed. The rear main oil seal retainer must also be removed first.*

1 Before the crankshaft can be withdrawn from the engine, the rear main oil seal retainer must be removed (see illustration) and the crankshaft endplay must be checked. Mount a dial indicator with the stem in line with the crankshaft and touching one of the crank throws (see illustration).

2 Push the crankshaft all the way to the rear and zero the dial indicator. Next, pry the crankshaft to the front as far as possible and check the reading on the dial indicator. The distance it moves is the endplay. If it's greater than listed in this Chapter's Specifications, check the crankshaft thrust surfaces for wear. If no wear is evident, new main bearings should correct the endplay.

3 If a dial indicator isn't available, feeler gauges can be used. Gently pry or push the crankshaft all the way to the front of the engine. Slip feeler gauges between the crankshaft and the front face of the thrust main bearing to determine the clearance (see illustration).

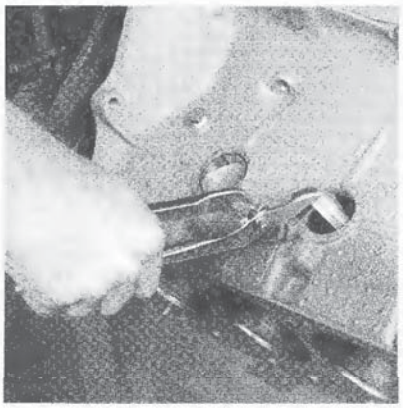
4 Check the main bearing caps to see if they're marked to indicate their locations. They should be numbered consecutively from the front of the engine to the rear (see illustration). If they aren't, mark them with number stamping dies or a centre-punch (see illustration). Main bearing caps generally



15.4a Main bearing caps are typically marked to indicate their locations (arrows) - they should be numbered consecutively from the front of the engine to the rear

15.4b The arrow on the main bearing cap indicates the front of the engine. Mark the caps to indicate their positions with a centrepunch

16.4a A hammer and large punch can be used to knock the core plugs sideways in their bores



16.4b Pull the core plugs from the block with pliers

16.8 All bolt holes in the block - particularly the main bearing cap and head bolt holes - should be cleaned and restored with a tap (be sure to remove debris from the holes after this is done)

have a cast-in arrow, which points to the front of the engine. Loosen the main bearing cap bolts 1/4-turn at a time each, until they can be removed by hand. Note if any stud bolts are used and make sure they're returned to their original locations when the crankshaft is refitted.

Note: *On V6 models there are side bolts for the main caps that must be removed before removing the caps.*

5 On V6 models, main caps are "press-fit" into the block, and the factory recommends using a special tool (J41348) to pull caps out of the block. The special tool is a steel plate that attaches with two bolts to the main cap (after the main cap bolts are removed). To this plate you attach a slide hammer and gently pull the cap straight out of the block.

6 Remove the rear main oil seal retainer plate before removing the crankshaft from V6 models.

7 Carefully lift the crankshaft straight out of the engine. It may be a good idea to have an assistant available, since the crankshaft is quite heavy. With the bearing inserts in place in the engine block and main bearing caps, return the caps to their respective locations on the engine block and tighten the bolts finger tight.

16 Engine block - cleaning

Refer to illustrations 16.4a, 16.4b, 16.8 and 16.10

1 Remove the main bearing caps and separate the bearing inserts from the caps and the engine block. Tag the bearings, indicating which cylinder they were removed from and whether they were in the cap or the block, then set them aside.

2 Using a gasket scraper, remove all traces of gasket material from the engine block. Be very careful not to nick or gouge the gasket sealing surfaces.

3 Remove all of the covers and threaded oil gallery plugs from the block. The plugs are usually very tight - they may have to be drilled out and the holes retapped. Use new plugs when the engine is reassembled.

4 Remove the core plugs from the engine block. To do this, knock one side of the plugs into the block with a hammer and punch, then grasp them with large pliers and pull them out (see illustrations).

5 If the engine is extremely dirty, it should be taken to an automotive machine shop to be cleaned.

Note: *If the block is cleaned in a caustic-solution hot tank, this will ruin any camshaft or balance-shaft bearings left in the block. If the engine is being rebuilt, these bearings should be renewed anyway.*

6 After the block is returned, clean all oil holes and oil galleries one more time. Brushes specifically designed for this purpose are available at most auto parts stores. Flush the passages with warm water until the water runs clear, dry the block thoroughly and wipe all machined surfaces with a light, rust preventive oil. If you have access to compressed air, use it to speed the drying process and blow out all the oil holes and galleries.

Warning: *Wear eye protection when using compressed air!*

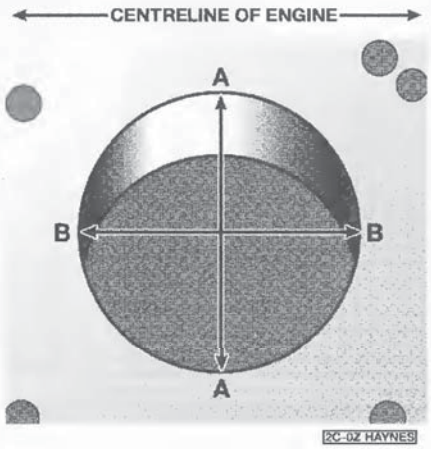
7 If the block isn't extremely dirty or sludged up, you can do an adequate cleaning job with hot soapy water and a stiff brush. Take plenty of time and do a thorough job. Regardless of the cleaning method used, be sure to clean all oil holes and galleries very thoroughly, dry the block completely and coat all machined surfaces with light oil.

8 The threaded holes in the block must be clean to ensure accurate torque readings during reassembly. Run the proper size tap into each of the holes to remove rust, corrosion, thread sealant or sludge and restore damaged threads (see illustration). If possible, use compressed air to clear the holes of debris produced by this operation. Now is a good time to clean the threads on the head bolts and the main bearing cap bolts as well.

9 Refit the main bearing caps and tighten the bolts finger tight.

10 After coating the sealing surfaces of the new core plugs with a hard-setting sealant (such as Permatex no. 1), fit them in the

16.10 A large socket on an extension can be used to drive the new core plugs into the bores



17.4a Measure the diameter of each cylinder just under the wear ridge, at the centre and at the bottom. Measure in both the A and B directions

engine block (see illustration). Make sure they're driven in straight and seated properly or leakage could result. Special tools are available for this purpose, but a large socket, with an outside diameter that will just slip into the core plug, a large extension and a hammer will work just as well.

11 Apply non-hardening sealant (such as Teflon pipe sealant) to the new oil gallery plugs and thread them into the holes in the block. Make sure they're tightened securely.

12 If the engine isn't going to be reassembled right away, cover it with a large plastic trash bag to keep it clean.

17 Engine block - inspection

Refer to illustrations 17.4a, 17.4b and 17.4c

Note: *The manufacturer recommends checking the block deck for warpage and the main bearing bore concentricity and alignment. Since special measuring tools are needed, the checks should be done by an automotive machine shop.*

1 Before the block is inspected, it should be cleaned as described in Section 16.

2 Visually check the block for cracks, rust and corrosion. Look for stripped threads in the threaded holes. It's also a good idea to have the block checked for hidden cracks by an automotive machine shop that has the special equipment to do this type of work. If defects are found, have the block repaired, if possible, or renewed.

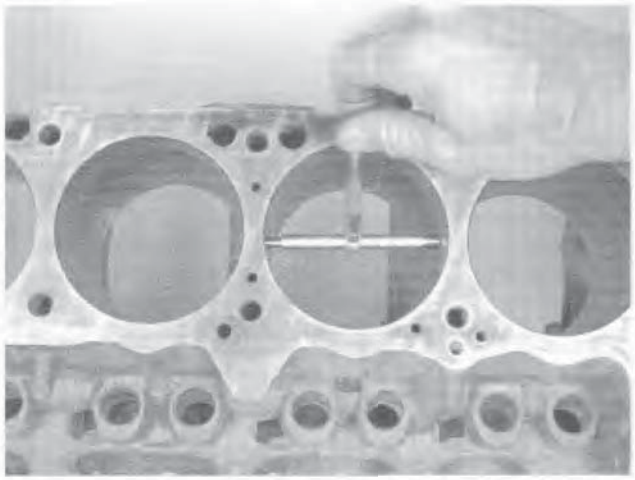
3 Check the cylinder bores for scuffing and scoring.

4 Check the cylinders for taper and out-of-round conditions as follows (see illustrations):

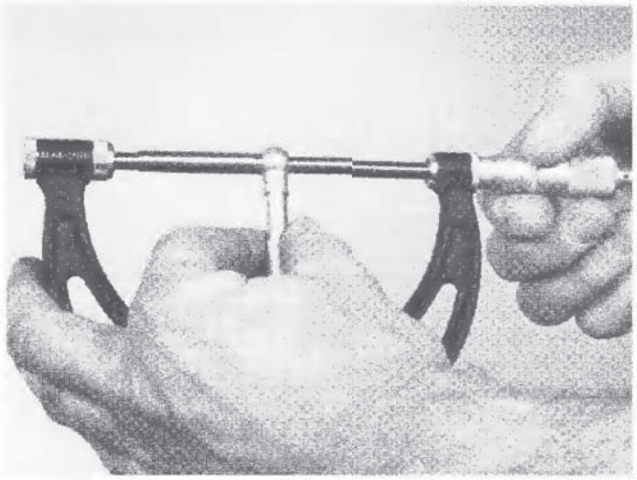
5 Measure the diameter of each cylinder at the top (just under the ridge area), centre and bottom of the cylinder bore, parallel to the crankshaft axis.

6 Next, measure each cylinder's diameter at the same three locations perpendicular to the crankshaft axis.

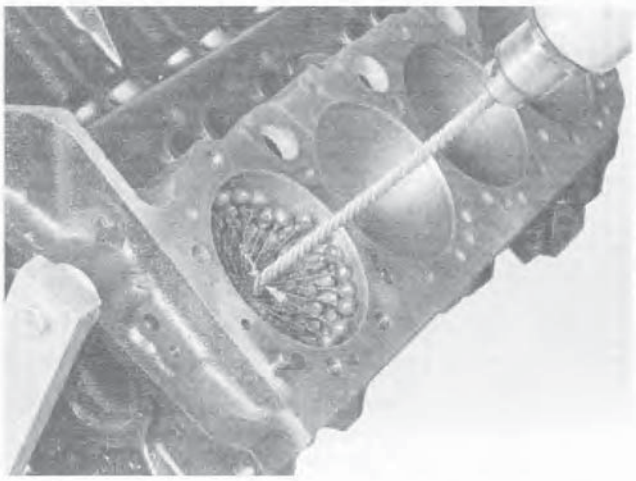
7 The taper of each cylinder is the difference between the bore diameter at the top of the cylinder and the diameter at the bottom. The out-of-round specification of the cylinder bore is



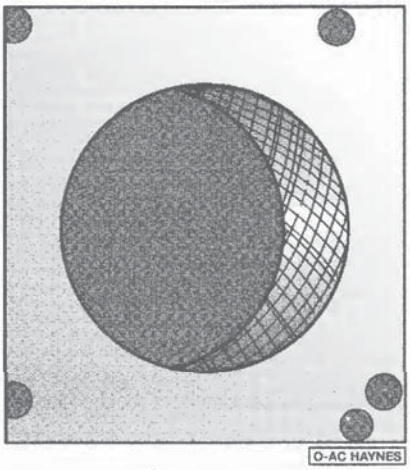
17.4b The ability to "feel" when the telescoping gauge is at the correct point will be developed over time, so work slowly and repeat the check until you're satisfied the bore measurement is accurate



17.4c The gauge is then measured with a micrometer to determine the bore size



18.3a A "bottle brush" hone will produce better results if you've never honed cylinders before



18.3b The cylinder hone should leave a smooth, crosshatch pattern with the lines intersecting at approximately a 60-degree angle

the difference between the parallel and perpendicular readings. Compare your results to this Chapter's Specifications.

8 If the cylinder walls are badly scuffed or scored, or if they're out-of-round or tapered beyond the limits given in this Chapter's Specifications, have the engine block rebored and honed at an automotive machine shop.

9 If a rebore is done, oversize pistons and rings will be required.

10 Using a precision straightedge and feeler gauge, check the block deck (the surface the cylinder heads mate with) for distortion as you did with the cylinder heads (see Section 10). If it's distorted beyond the limit given in this Chapter's Specifications, the block decks can be resurfaced by an automotive machine shop.

11 If the cylinders are in reasonably good condition and not worn to the outside of the limits, and if the piston-to-cylinder clearances can be maintained properly, they don't have to be rebored. Honing is all that's necessary (see Section 18).

18 Cylinder honing

Refer to illustrations 18.3a and 18.3b

1 Prior to engine reassembly, the cylinder bores must be honed so the new piston rings will seat correctly and provide the best possible combustion chamber seal.

> ***Note:*** *If you don't have the tools or don't want to tackle the honing operation, most automotive machine shops will do it for a reasonable fee.*

2 Before honing the cylinders, refit the main bearing caps and tighten the bolts to the torque listed in this Chapter's Specifications.

3 Two types of cylinder hones are commonly available - the flex hone or "bottle brush" type and the more traditional surfacing hone with spring-loaded stones. Both will do the job, but the "bottle brush" hone will probably produce better results. You'll also need some honing oil (kerosene will work if honing oil isn't available), rags and an electric drill motor. Proceed as follows:

a) Mount the hone in the drill motor, compress the stones and slip it into the first cylinder (see illustration). Be sure to wear safety goggles or a face shield!

b) Lubricate the cylinder with plenty of honing oil, turn on the drill and move the hone up-and-down in the cylinder at a pace that will produce a fine crosshatch pattern on the cylinder walls, and with the drill square and centered with the bore. Ideally, the crosshatch lines should intersect at approximately a 45-60-degree angle (see illustration). Be sure to use plenty of lubricant and don't take off any more material than is absolutely necessary to produce the desired finish.

> ***Note:*** *Piston ring manufacturers may specify a different crosshatch angle - read and follow any instructions included with the new rings.*

c) Don't withdraw the hone from the cylinder while it's running. Instead, shut off the drill and continue moving the hone up-and-down in the cylinder until it comes to a complete stop, then compress the stones and withdraw the hone. If you're using a "bottle brush" type hone, stop the drill motor, then turn the chuck in the normal direction of rotation while withdrawing the hone from the cylinder.

d) Wipe the oil out of the cylinder and repeat the procedure for the remaining cylinders.

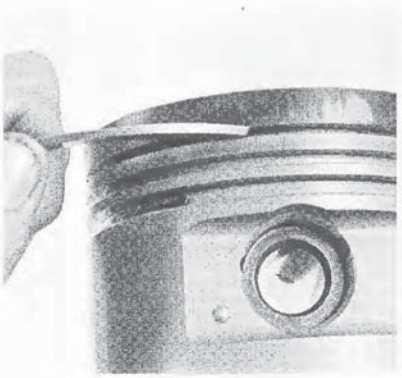
4 After the honing job is complete, chamfer the top edges of the cylinder bores with a small file so the rings won't catch when the pistons are refitted. Be very careful not to nick the cylinder walls with the end of the file.

5 The entire engine block must be washed again very thoroughly with warm, soapy water to remove all traces of the abrasive grit produced during the honing operation.

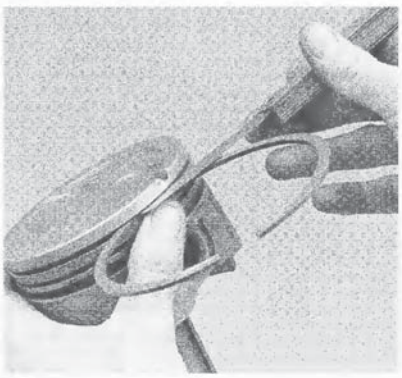
> ***Note:*** *The bores can be considered clean when a lint-free white cloth - dampened with clean engine oil - used to wipe them out doesn't pick up any more honing residue, which will show up as gray areas on the cloth. Be sure to run a brush through all oil holes and galleries and flush them with running water.*

6 After rinsing, dry the block and apply a coat of light rust preventive oil to all machined surfaces. Wrap the block in a plastic trash bag to keep it clean and set it aside until reassembly.

19.4a The piston ring grooves can be cleaned with a special tool, as shown here ...



19.4b ... or a section of broken ring



19.10 Check the ring side clearance with a feeler gauge at several points around the groove

19 Pistons and connecting rods - inspection

Refer to illustrations 19.4a, 19.4b, 19.10 and 19.11

1 Before the inspection process can be carried out, the piston/connecting rod assemblies must be cleaned and the original piston rings removed from the pistons.

> ***Note:*** *Always use new piston rings when the engine is reassembled.*

2 Using a piston ring refitting tool, carefully remove the rings from the pistons. Be careful not to nick or gouge the pistons in the process.

3 Scrape all traces of carbon from the top of the piston. A hand-held wire brush or a piece of fine emery cloth can be used once the majority of the deposits have been scraped away. Do not, under any circumstances, use a wire brush mounted in a drill motor to remove deposits from the pistons. The piston material is soft and may be eroded away by the wire brush.

4 Use a piston ring groove-cleaning tool to remove carbon deposits from the ring grooves. If a tool isn't available, a piece broken off the old ring will do the job. Be very careful to remove only the carbon deposits - don't remove any metal and do not nick or scratch the sides of the ring grooves (see illustrations).

5 Once the deposits have been removed, clean the piston/rod assemblies with solvent and dry them with compressed air (if available).

> ***Warning:*** *Wear eye protection. Make sure the oil return holes in the back sides of the ring grooves are clear.*

6 If the pistons and cylinder walls aren't damaged or worn excessively, and if the engine block isn't rebored, new pistons won't be necessary. Normal piston wear appears as even vertical wear on the piston thrust surfaces and slight looseness of the top ring in its groove. New piston rings, however, should always be used when an engine is rebuilt.

7 Carefully inspect each piston for cracks around the skirt, at the pin bosses and at the ring lands.

8 Look for scoring and scuffing on the thrust faces of the skirt, holes in the piston crown and burned areas at the edge of the crown. If the skirt is scored or scuffed, the engine may have been suffering from overheating and/or abnormal combustion, which caused excessively high operating temperatures. The cooling and lubrication systems should be checked thoroughly. A hole in the piston crown is an indication that abnormal combustion (preignition) was occurring. Burned areas at the edge of the piston crown are usually evidence of spark knock (detonation). If any of the above problems exist, the causes must be corrected or the damage will occur again. The causes may include inlet air leaks, incorrect fuel/air mixture, low octane fuel, ignition timing and EGR system malfunctions.

9 Corrosion of the piston, in the form of small pits, indicates coolant is leaking into the combustion chamber and/or the crankcase. Again, the cause must be corrected or the problem may persist in the rebuilt engine.

10 Measure the piston ring side clearance by laying a new piston ring in each ring groove and slipping a feeler gauge in beside it (see illustration). Check the clearance at three or four locations around each groove. Be sure to use the correct ring for each groove - they are different. If the side clearance is greater than specified in this Chapter, new pistons will have to be used.

11 Check the piston-to-bore clearance by measuring the bore (see Section 17) and the piston diameter. Make sure the pistons and bores are correctly matched. Measure the piston across the skirt, at a 90-degree angle to the piston pin (see illustration). The measurement must be taken at a specific point, depending on the engine, to be accurate. See the Specifications in this Chapter for the correct measuring point.

12 Subtract the piston diameter from the bore diameter to obtain the clearance. If it's greater than specified, the block will have to be rebored and new oversize pistons and rings fitted.

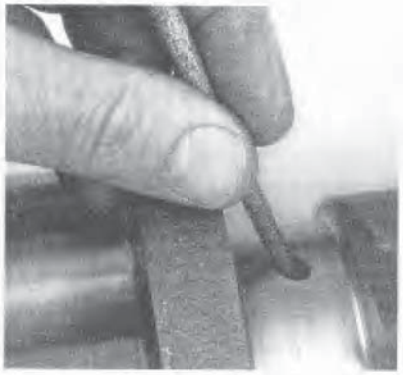
13 Check the piston pin-to-rod clearance by twisting the piston and rod in opposite directions. Any noticeable play indicates excessive wear, which must be corrected by replacing the pistons.

14 If the pistons must be removed from the connecting rods for any reason, they should be taken to an automotive machine shop. While they are there, have the connecting rods checked for bend and twist, in addition to big end sizing, since automotive machine shops have special equipment for this purpose.

> ***Note:*** *Unless new pistons and/or connecting rods must be fitted, do not disassemble the pistons and connecting rods.*

15 Check the connecting rods for cracks and other damage. Temporarily remove the rod caps, lift out the old bearing inserts, wipe the rod and cap bearing surfaces clean and

19.11 Measure the piston diameter at a 90-degree angle to the piston pin and in line with it



20.1 The oil holes should be chamfered so sharp edges don't gouge or scratch the new bearings

20.2 Use a wire or stiff plastic bristle brush to clean the oil passages in the crankshaft

inspect them for nicks, gouges and scratches. After checking the rods, renew the old bearings, slip the caps into place and tighten the nuts finger tight.

> ***Note:*** *If the engine is being rebuilt because of a connecting rod knock, be sure to fit new rods or have the old rods reconditioned.*

16 On V8 engines only, the "GM" casting mark on each connecting rod must face the same direction as the notch on the piston crown on cylinders 1, 3, 5 and 7. The mark must face in the opposite direction for the other cylinders.

20 Crankshaft - inspection

Refer to illustrations 20.1, 20.2, 20.3, 20.5 and 20.7

1 Remove all burrs from the crankshaft oil holes with a stone, file or scraper (see illustration).

2 Clean the crankshaft with solvent and dry it with compressed air (if available).

> ***Warning:*** *Wear eye protection when using compressed air.*

Be sure to clean the oil holes with a stiff brush (see illustration) and flush them with solvent.

3 Check the main and connecting rod bearing journals for uneven wear, scoring, pits and cracks (see illustration).

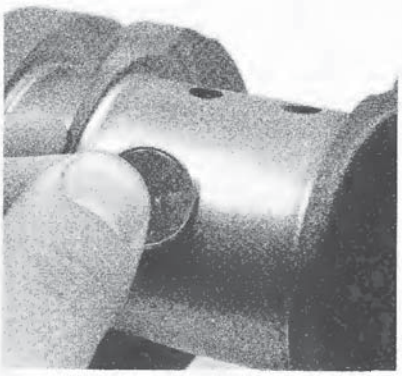
4 Check the rest of the crankshaft for cracks and other damage. It should be Magnafluxed to reveal hidden cracks - an automotive machine shop will handle the procedure.

5 Using a micrometer, measure the diameter of the main and connecting rod journals and compare the results to this Chapter's Specifications (see illustration). By measuring the diameter at a number of points around each journal's circumference, you'll be able to determine whether or not the journal is out-of-round. Take the measurement at each end of the journal, near the crank throws, to determine if the journal is tapered.

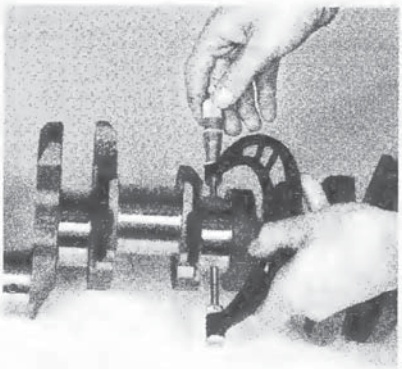
6 If the crankshaft journals are damaged, tapered, out-of-round or worn beyond the limits given in the Specifications, have the crankshaft reground by an automotive machine shop. Be sure to use the correct-size bearing inserts if the crankshaft is reconditioned.

7 Check the oil seal journals at each end of the crankshaft for wear and damage. If the seal has worn a groove in the journal, or if it's nicked or scratched (see illustration), the new seal may leak when the engine is reassembled. In some cases, an automotive machine shop may be able to repair the journal by pressing on a thin sleeve. If repair isn't feasible, a new or different crankshaft should be fitted.

8 Examine the main and rod bearing inserts (see Section 21).



20.3 Rubbing a penny lengthwise on each journal will reveal its condition - if copper rubs off and is embedded in the crankshaft, the journals should be reground



20.5 Measure the diameter of each crankshaft journal at several points to detect taper and out-of-round conditions

20.7 If the seals have worn grooves in the crankshaft journals, or if the seal contact surfaces are nicked or scratched, the new seals will leak

21 Main and connecting rod bearings - inspection

Refer to illustration 21.1

1 Even though the main and connecting rod bearings should be renewed with new ones during the engine overhaul, the old bearings should be retained for close examination, as they may reveal valuable information about the condition of the engine (see illustration).

2 Bearing failure occurs because of lack of lubrication, the presence of dirt or other foreign particles, overloading the engine and corrosion. Regardless of the cause of bearing failure, it must be corrected before the engine is reassembled to prevent it from happening again.

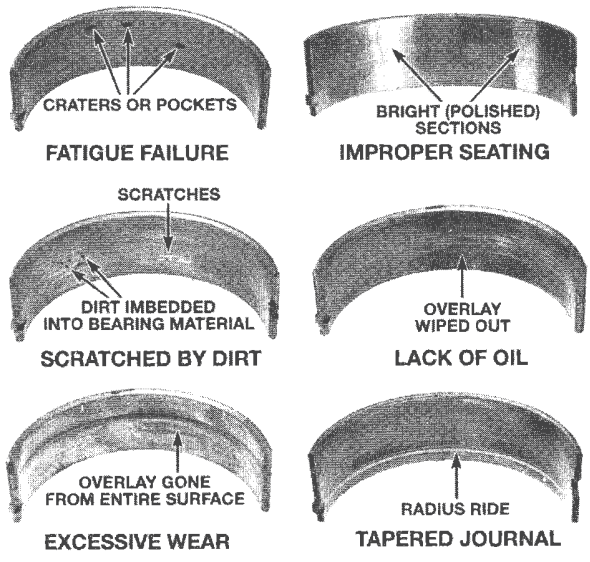
3 When examining the bearings, remove them from the engine block, the main bearing caps, the connecting rods and the rod caps and lay them out on a clean surface in the same general position as their location in the engine. This will enable you to match any bearing problems with the corresponding crankshaft journal.

4 Dirt and other foreign particles get into the engine in a variety of ways. It may be left in the engine during assembly, or it may pass through filters or the PCV system. It may get into the oil, and from there into the bearings. Metal chips from machining operations and normal engine wear are often present. Abrasives are sometimes left in engine components after reconditioning, especially when parts aren't thoroughly cleaned using the proper cleaning methods. Whatever the source, these foreign objects often end up embedded in the soft bearing material and are easily recognised. Large particles won't embed in the bearing and will score or gouge the bearing and journal. The best prevention for this cause of bearing failure is to clean all parts thoroughly and keep everything spotlessly clean during engine assembly. Frequent and regular engine oil and filter changes are also recommended.

5 Lack of lubrication (or lubrication breakdown) has a number of interrelated causes. Excessive heat (which thins the oil), overloading (which squeezes the oil from the bearing face) and oil leakage or throw off (from excessive bearing clearances, worn oil pump or high engine speeds) all contribute to lubrication breakdown. Blocked oil passages, which usually are the result of misaligned oil holes in a bearing shell, will also oil starve a bearing and destroy it. When lack of lubrication is the cause of bearing failure, the bearing material is wiped or extruded from the steel backing of the bearing. Temperatures may increase to the point where the steel backing turns blue from overheating.

6 Driving habits can have a definite effect on bearing life. Low speed operation in too high a gear (lugging the engine) puts very high loads on bearings, which tends to squeeze out the oil film. These loads cause the bearings to flex, which produces fine cracks in the bearing face (fatigue failure). Eventually the bearing material will loosen in pieces and tear away from the steel backing. Short trip driving leads to corrosion of bearings because insufficient engine heat is produced to drive off the condensed water and corrosive gases. These products collect in the engine oil, forming acid and sludge. As the oil is carried to the engine bearings, the acid attacks and corrodes the bearing material.

7 Incorrect bearing refitting during engine assembly will lead to bearing failure as well. Tight-fitting bearings leave insufficient oil clearance and will result in oil starvation. Dirt or foreign particles trapped behind a bearing insert result in high spots on the bearing which lead to failure.



21.1 Typical bearing failures

22 Engine overhaul - reassembly sequence

1 Before beginning engine reassembly, make sure you have all the necessary new parts, gaskets and seals as well as the following items on hand:

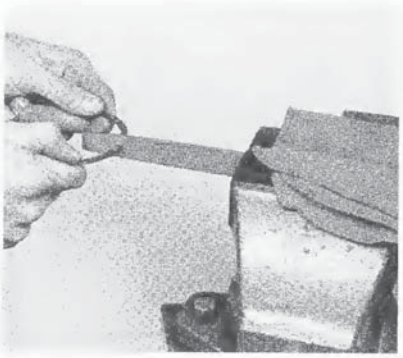
Common hand tools
Torque wrench (1/2-inch drive) with angle-torque gauge
Piston ring refitting tool
Piston ring compressor
Crankshaft balancer refitting tool
Short lengths of rubber or plastic hose to fit over connecting rod bolts
Plastigage
Feeler gauges
Fine-tooth file
New engine oil
Engine assembly lube or moly-base grease
Gasket sealant
Thread locking compound

2 In order to save time and avoid problems, engine reassembly must be done in the following general order:

Rear oil seal (V8 models)
Crankshaft and main bearings
Piston/connecting rod assemblies
Balance shaft (V6 models)
Camshaft
Rear main oil seal (V6 models)
Timing chain and sprockets
Timing chain cover and oil pump
Sump
Cylinder heads
Valve lifters
Rocker arms and pushrods
Driveplate
Assembled after engine refitting:
Inlet and exhaust manifolds
Valve covers

23.3 When checking piston ring end gap, the ring must be square in the cylinder bore (this is done by pushing the ring down with the top of a piston as shown)

23.4 With the ring square in the cylinder, measure the end gap with a feeler gauge



23.5 If the end gap is too small, clamp a file in a vise and file the ring ends (from the outside in only) to enlarge the gap slightly

23 Piston rings - refitting

Refer to illustrations 23.3, 23.4, 23.5, 23.9a, 23.9b, 23.12 and 23.15

1 Before fitting the new piston rings, the ring end gaps must be checked. It's assumed the piston ring side clearance has been checked and verified correct (see Section 19).

2 Lay out the piston/connecting rod assemblies and the new ring sets so the ring sets will be matched with the same piston and cylinder during the end gap measurement and engine assembly.

3 Insert the top (number one) ring into the first cylinder and square it up with the cylinder walls by pushing it in with the top of the piston (see illustration). The ring should be near the bottom of the cylinder, at the lower limit of ring travel.

4 To measure the end gap, slip feeler gauges between the ends of the ring until a gauge equal to the gap width is found (see illustration). The feeler gauge should slide between the ring ends with a slight amount of drag. Compare the measurement to this Chapter's Specifications. If the gap is larger or smaller than specified, double-check to make sure you have the correct rings before proceeding.

5 If the gap is slightly too small, it must be enlarged or the ring ends may come in contact with each other during engine operation, which can cause serious engine damage. The end gap can be slightly increased by filing the ring ends very carefully with a fine file. Mount the file in a vise equipped with soft jaws, slip the ring over the file with the ends contacting the file teeth and slowly move the ring to remove material from the ends. When performing this operation, file only from the outside in (see illustration).

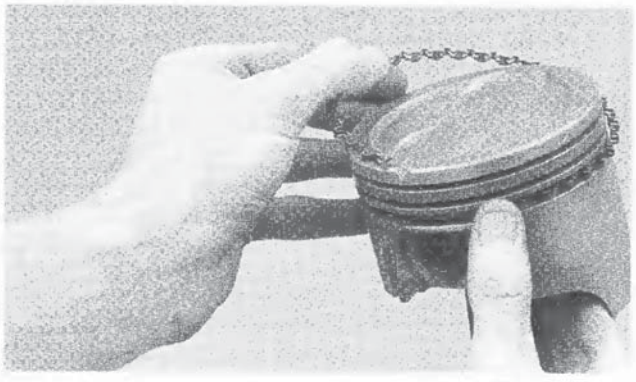
Note: *When you have the end gap correct, remove any burrs from the filed ends of the rings with a whetstone.*

6 Excess end gap isn't critical unless it's greater than 1.0 mm. Again, double-check to make sure you have the correct rings for the engine. If the engine block has been bored oversize, necessitating oversize pistons, matching oversize rings are required.

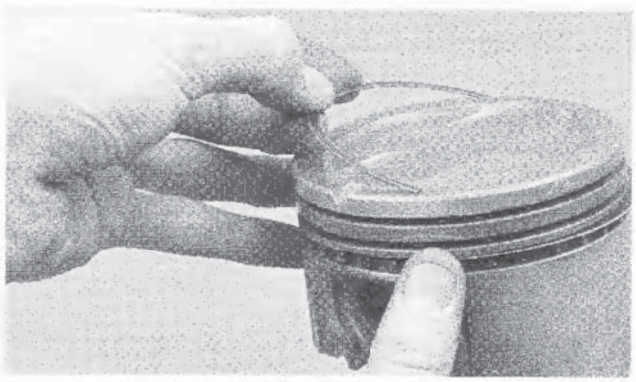
7 Repeat the procedure for each ring that will be refitted in the first cylinder and for each ring in the remaining cylinders. Remember to keep rings, pistons and cylinders matched up.

8 Once the ring end gaps have been checked/corrected, the rings can be refitted on the pistons.

9 The oil control ring (lowest one on the piston) is usually refitted first. It's composed of three separate components. Slip the spacer/expander into the groove (see illustration). If an anti-rotation tang is used, make sure it's inserted into the drilled hole in the ring groove. Next, refit the lower side rail. Don't use a piston ring refitting tool on the oil ring side rails, as they may be damaged. Instead, place one end of the side rail into the groove between the spacer/expander and the ring land, hold it firmly in place and slide a finger around the piston while pushing the rail into the groove (see illustration). Next, refit the upper side rail in the same manner.

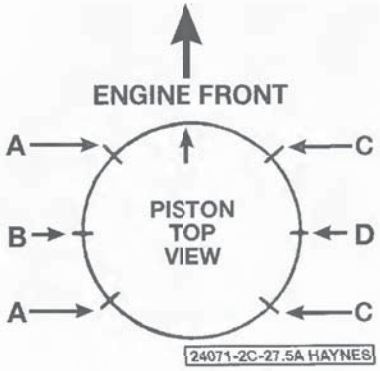


23.9a Refitting the spacer/expander in the oil control ring groove



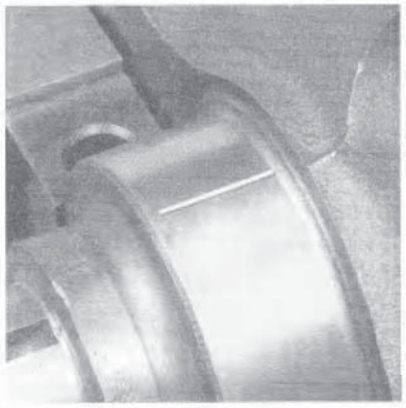
23.9b DO NOT use a piston ring refitting tool when refitting the oil ring side rails

23.12 Refitting the compression rings with a ring expander - the mark (arrow) must face up



23.15 Piston ring and gap positions

- *A Oil ring rail gaps*
- *B Second compression ring gap*
- *C Oil ring spacer gap (position between marks)*
- *D Top compression ring gap*



24.11 Lay the Plastigage strips on the main bearing journals, parallel to the crankshaft centreline

10 After the three oil ring components have been refitted, check to make sure both the upper and lower side rails can be turned smoothly in the ring groove. Check that the ends of the expander do not overlap.

11 The number two (middle) ring is refitted next. It's usually stamped with a mark, which must face up, toward the top of the piston.

> ***Note:*** *Always follow the instructions printed on the ring package or box - different manufacturers may require different approaches. Don't mix up the top and middle rings, as they have different cross-sections.*

12 Use a piston ring refitting tool and make sure the identification mark is facing the top of the piston, then slip the ring into the middle groove on the piston (see illustration). Don't expand the ring any more than necessary to slide it over the piston.

13 Refit the number one (top) ring in the same manner. Make sure the mark is facing up. Be careful not to confuse the number one and number two rings.

14 Repeat the procedure for the remaining pistons and rings.

15 Stagger the gaps properly (see illustration).

24 Crankshaft - refitting and main bearing oil clearance check

1 Crankshaft refitting is the first step in engine reassembly. It's assumed at this point that the engine block and crankshaft have been cleaned, inspected and repaired or reconditioned.

2 Position the engine with the bottom facing up.

3 Remove the main bearing cap bolts and lift out the caps (see Section 15 for the procedure). Lay them out in the proper order to ensure correct refitting.

4 If they're still in place, remove the original bearing inserts from the block and the main bearing caps. Wipe the bearing surfaces of the block and caps with a clean, lint-free cloth. They must be kept spotlessly clean.

MAIN BEARING OIL CLEARANCE CHECK

Refer to illustrations 24.11, 24.13 and 24.15

> ***Note:*** *Don't touch the faces of the new bearing inserts with your fingers. Oil and acids from your skin can etch the bearings.*

5 Clean the back sides of the new main bearing inserts and lay one in each main bearing saddle in the block. If one of the bearing inserts from each set has a large groove in it, make sure the grooved insert is refitted in the block. Lay the other bearing from each set in the corresponding main bearing cap. Make sure the tab on the bearing insert fits into the recess in the block or cap, neither higher than the cap's edge nor lower.

> ***Caution:*** *The oil holes in the block must line up with the oil holes in the bearing inserts. Do not hammer the bearing into place and don't nick or gouge the bearing faces. No lubrication should be used at this time.*

6 The flanged thrust bearing must be refitted in the number two bearing position (counting from the front of the engine) on V6 engines or the rear main bearing position on V8 engines.

7 Clean the faces of the bearings in the block and the crankshaft main bearing journals with a clean, lint-free cloth.

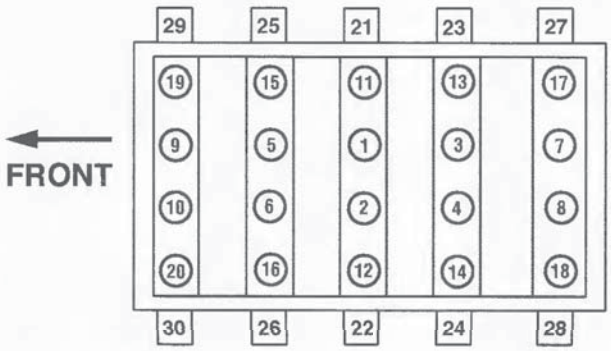
8 Check or clean the oil holes in the crankshaft, as any dirt here can go only one way - straight through the new bearings.

9 Once you're certain the crankshaft is clean, carefully lay it in position in the main bearings.

10 Before the crankshaft can be permanently refitted, the main bearing oil clearance must be checked.

11 Cut several pieces of the appropriate size Plastigage (they should be slightly shorter than the width of the main bearings) and place one piece on each crankshaft main bearing journal, parallel with the journal axis (see illustration).

12 Clean the faces of the bearings in the caps and refit the caps in their original locations (don't mix them up) with the arrows pointing towards the front of the engine. Don't disturb the Plastigage.



24.13 Main bearing cap TIGHTENING sequence - 5.7 litre generation III V8 engine

24.15 Measuring the width of the crushed Plastigage to determine the main bearing oil clearance (be sure to use the correct scale - standard and metric ones are included)

13 Starting with the centre main and working out toward the ends, tighten the main bearing cap bolts 1/2 turn at a time until the caps are properly seated in the block. Don't rotate the crankshaft at any time during this operation, and do not tighten one cap completely - tighten all caps equally.

> ***Caution:*** *On V6 engines, the caps must be brought into place by pulling them down with the bolts. Do not tap them with a hammer.*

When all the caps are seated, tighten the bolts to the torque listed in this Chapter's Specifications. On 5.7 litre Generation III V8 engines, use the following sequence (see illustration):

a) Tighten the inner bolts (1 through 10) to 20 Nm
b) Tighten the inner bolts (1 through 10) an additional 80 degrees
c) Tighten the inner bolts (11 through 20) to 20 Nm
d) Tighten the inner bolts (11 through 20) an additional 53 degrees
e) Tighten the NEW side bolts (21 through 30) to 25 Nm
f) DO NOT use the new side bolts during the oil clearance check as this will damage the sealant patch applied to bolt flanges

Don't rotate the crankshaft at any time during this operation, and do not tighten one cap completely - tighten all caps equally.

14 Remove the bolts and carefully lift off the main bearing caps. Keep them in order. Don't disturb the Plastigage or rotate the crankshaft.

> ***Note:*** *Refer to Section 15 for the correct cap removal procedure.*

15 Compare the width of the crushed Plastigage on each journal to the scale printed on the Plastigage envelope to obtain the main bearing oil clearance (see illustration). Check the Specifications to make sure it's correct.

16 If the clearance is not as specified, the bearing inserts may be the wrong size (which means different ones will be required). Before deciding different inserts are needed, make sure no dirt or oil was between the bearing inserts and the caps or block when the clearance was measured. If the Plastigage was wider at one end than the other, the journal may be tapered (see Section 20).

17 Carefully scrape all traces of the Plastigage material off the main bearing journals and/or the bearing faces. Use your fingernail or the edge of a credit card - don't nick or scratch the bearing faces.

FINAL CRANKSHAFT REFITTING

18 Carefully lift the crankshaft out of the engine. Clean the bearing faces in the block, then apply a thin, uniform layer of moly-base grease or engine assembly lube to each of the bearing surfaces. Be sure to coat the thrust faces as well as the journal face of the thrust bearing.

19 On V8 models, renew the rear main oil seal (see Section 26).

20 Make sure the crankshaft journals are clean, then lay the crankshaft back in place in the block.

21 Clean the faces of the bearings in the caps, then apply lubricant to them.

22 Refit the caps in their original locations with the arrows pointing toward the front of the engine.

23 Starting at the centre and working out towards the ends, tighten the main bearing cap bolts 1/2 turn at a time until the caps are seated on the engine block.

> ***Caution:*** *On V6 models the caps must be brought into place by pulling them down with the bolts. Do not tap on them with a hammer.*

> ***Note:*** *On 5.7 litre Generation III V8 follow the procedures outlined in Step 13.*

24 On V6 models, fit new main bearing cap side bolts hand-tight.

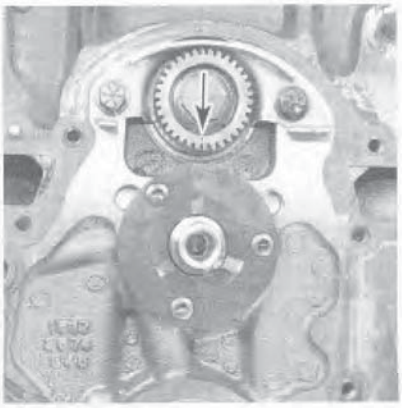
> ***Caution:*** *New side bolts must be used to ensure oil leaks do not develop at the bolt heads.*

25 Tap the ends of the crankshaft forward and backward with a lead or brass hammer to seat the main bearing and crankshaft thrust surfaces.

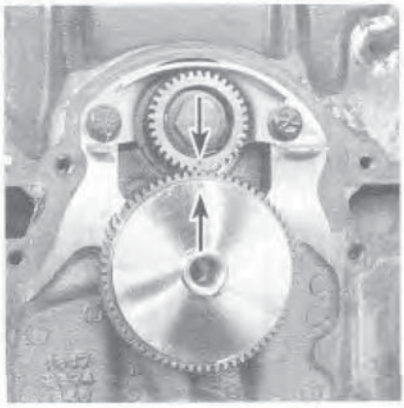
26 Tighten the main bearing cap bolts to the torque listed in this Chapter's Specifications, starting with the centre main and working out toward the ends. On V6 models, tighten the main bearing cap side bolts to the torque listed in this Chapter's Specifications.

27 Rotate the crankshaft a number of times by hand to check for any obvious binding.

25.1 Be sure to pre-lube the camshaft bearing journals and lobes before refitting



25.6 The balance shaft gear mark (arrow) should point straight down



25.7 Align the marks (arrows) on the balance shaft gears as shown here

28 Check the crankshaft endplay with feeler gauges or a dial indicator as described in Section 15. The endfloat should be correct if the crankshaft thrust faces aren't worn or damaged and new bearings have been fitted.

25 Camshaft and balance shaft - refitting

CAMSHAFT

Refer to illustration 25.1

1 Lubricate the camshaft bearing journals and cam lobes with clean engine oil or assembly lube (see illustration).

2 Slide the camshaft into the engine. Support the cam near the block and be careful not to scrape or nick the bearings. Refit the camshaft retainer plate and tighten the bolts to the torque listed in the Part A or B Specifications. The TOP marking faces upwards and out from the block on V6 models.

BALANCE SHAFT (V6 MODELS ONLY)

Refer to illustrations 25.6 and 25.7

3 Lubricate the front bearing and rear journal of the balance shaft with engine oil and insert the balance shaft carefully into the block. When the front bearing approaches the insert in the front of the block, use a hammer and an appropriate-size socket to drive the front bearing into its insert. Drive it in just enough to allow refitting of the balance shaft bearing retainer on later models.

4 Refit the balance shaft driven gear and its bolt. The notch on the back of the gear must engage with the pin on the front of the balance shaft.

> ***Note:*** *The balance shaft driven gear bolt can be tightened in two ways: It can be previously refitted holding the shaft in a vise while tightening the bolt or by tightening it after the drive gear has been refitted. Lock the drive gear by placing a bolt through one of the holes in the gear to protrude into a thrust plate hole in the block.*

5 Turn the camshaft so that with the camshaft sprocket temporarily refitted, its timing mark is straight down.

6 With the camshaft sprocket and the camshaft gear removed, turn the balance shaft so the timing mark on the gear points straight down (see illustration).

7 Refit the camshaft gear (that drives the balance shaft) onto the cam, aligning it with the keyway and align the marks on the balance shaft gear and the camshaft gear (see illustration) by turning the balance shaft.

8 Tighten the balance shaft retainer bolts.

9 Check the balance shaft endplay and compare your readings to those listed in this Chapter's Specifications.

26 Rear main oil seal - renewal

V6 MODELS

Refer to Chapter 2A for this procedure.

5.0 LITRE V8 MODELS

1 In Part C of this Chapter, the procedure is given for renewal of the rear main oil seal with the engine still in the vehicle and the crankshaft in place. The job is somewhat simpler when the engine is being overhauled, but refer to the illustrations and procedures in Part C first.

2 Remove the old rear seal from the block and the main bearing cap using pliers. Thoroughly clean the channel into which the seal fits.

3 Apply a small bead of retaining compound (such as Loctite 609) to the seal's block groove. Fit a section of new seal into the groove and force it into place using a hammer handle, working from the centre towards each end. Trim the ends using a sharp razor blade. Leave about 1 mm sticking up.

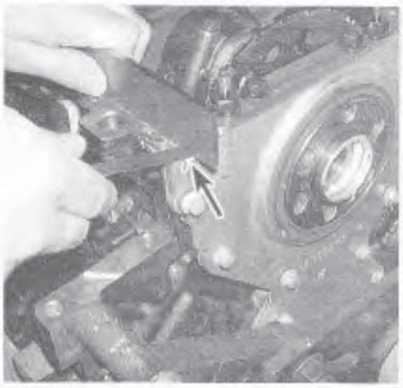
> ***Note:*** *When trimming the seal ends, use a backing to cut against in order to obtain a clean and square end.*

4 Refit the crankshaft (refer to Section 24).

5 Refit the lower seal to the main bearing cap as in Step 3. Trim the seal protrusions evenly with the cap.

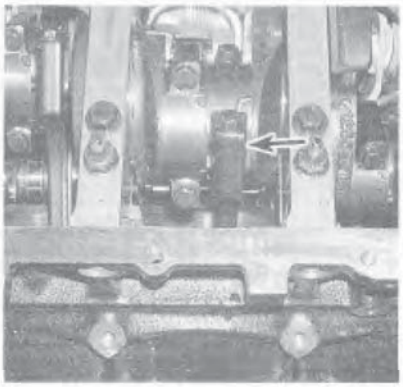
6 Apply sealant to the ends of the seal and across the cap mating surface in line with the seal. Apply a light coat of oil to the seal lip.

7 Refit the main bearing cap.



26.8 With the rear seal housing in place and the bolts refitted LOOSELY, measure the distance between the sump rail and the seal housing on each side (arrows) - then adjust the housing so the measurements are even on both sides before tightening the cover bolts

27.9a The notch or arrow on each piston must face the front end of the engine as the pistons are refitted



27.9b On 5.7 litre V8 engines, the flat side of the rods (arrow) and the notch in the top of the piston must face the front of the engine

5.7 LITRE GENERATION III V8 ENGINES AND 6.0 LITRE GENERATION IV V8

Refer to illustration 26.8

8 Refit the rear seal housing retaining bolts on the engine loosely and align the rear housing as follows:

a) Place a straightedge on the engine block sump rail. Measure the distance on each side of the block from the sump rail to the rear housing with a feelergauge (see illustration). This Step measures the difference between the sealing surface of the sump and the sealing surface of the rear seal housing in relationship to each other.

b) Tilt the rear seal housing as necessary to achieve an even measurement on each side. This Step properly aligns the rear seal housing to sump sealing surfaces. Typically 0 to 0.25 mm is an acceptable tolerance.

> ***Note:*** *Ideally the rear seal housing should be flush with the sump rail, but because of the differences in seal thickness, this may not always be obtainable. That is why there is a tolerance of 0 to 0.25 mm. Always let the rear seal centre itself around the crankshaft and tilt the cover from side-to-side to even up the measurement at both sump rails. Never push downward on the rear seal housing in an attempt to make the sump sealing surface flush, as this will distort the rear oil seal and eventually lead to an oil leak!*

c) With the rear seal housing properly aligned, tighten the housing bolts to the torque listed in this Chapter's Specifications.

27 Pistons and connecting rods - refitting and rod bearing oil clearance check

1 Before refitting the piston/connecting rod assemblies, the cylinder walls must be perfectly clean, the top edge of each cylinder must be chamfered, and the crankshaft must be in place.

2 Remove the cap from the end of the number one connecting rod (check the marks made during removal). Remove the original bearing inserts and wipe the bearing surfaces of the connecting rod and cap with a clean, lint-free cloth. They must be kept spotlessly clean.

PISTON REFITTING AND ROD BEARING OIL CLEARANCE CHECK

Refer to illustrations 27.9a, 27.9b, 27.11, 27.13 and 27.17

> ***Note:*** *Don't touch the faces of the new bearing inserts with your fingers. Oil and acids from your skin can etch the bearings.*

3 Clean the back side of the new upper bearing insert, then lay it in place in the connecting rod. Make sure the tab on the bearing fits into the recess in the rod. Don't hammer the bearing insert into place and be very careful not to nick or gouge the bearing face. Don't lubricate the bearing at this time.

4 Clean the back side of the other bearing insert and refit it in the rod cap. Again, make sure the tab on the bearing fits into the recess in the cap, and don't apply any lubricant. It's critically important that the mating surfaces of the bearing and connecting rod are perfectly clean and oil free when they're assembled.

5 Stagger the piston ring gaps around the piston (see illustration 23.15).

6 Slip a section of plastic or rubber hose over each connecting rod cap bolt.

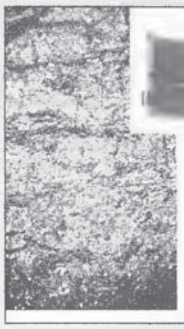
7 Lubricate the piston and rings with clean engine oil and attach a piston ring compressor to the piston. Leave the skirt protruding about 5 mm to guide the piston into the cylinder. The rings must be compressed until they're flush with the piston.

8 Rotate the crankshaft until the number one connecting rod journal is at BDC (bottom dead centre) and apply a coat of engine oil to the cylinder walls.

9 With the mark or notch on top of the piston facing the front of the engine (see illustration), gently insert the piston/connecting rod assembly into the number one cylinder bore and rest the bottom edge of the ring compressor on the engine block. On 5.7 litre V8 engines, the flat side of the connecting rods and the marks on the top of each piston must all face the front of the engine (see illustration). So, the

ENGINE BEARING ANALYSIS

Debris



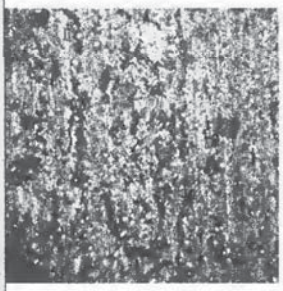
Babbitt bearing embedded with debris from machinings

Microscopic detail of debris

Microscopic detail of gouges

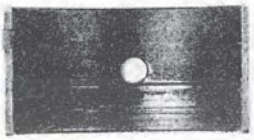
Overplated copper alloy bearing gouged by cast iron debris

Aluminum bearing embedded with glass beads



Microscopic detail of glass beads

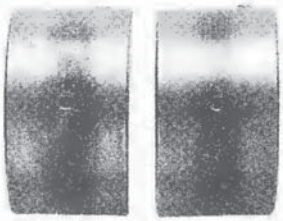
Damaged lining caused by dirt left on the bearing back



Misassembly

Result of a lower half assembled as an upper - blocking the oil flow

Excessive oil clearance is indicated by a short contact arc

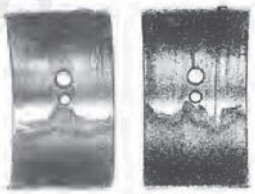


Polished and oil-stained backs are a result of a poor fit in the housing bore

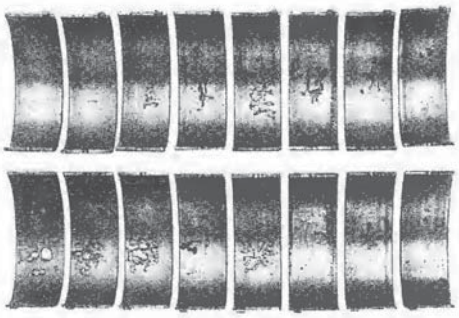
Result of a wrong, reversed, or shifted cap

Overloading

Damage from excessive idling which resulted in an oil film unable to support the load imposed

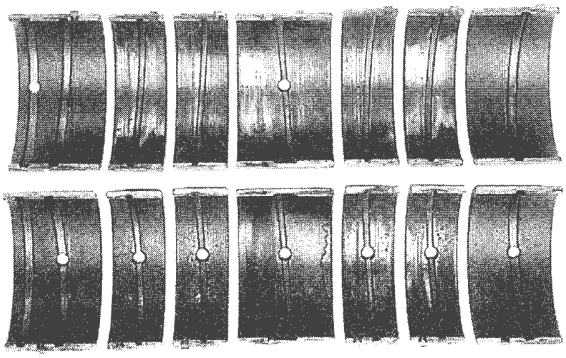


Damaged upper connecting rod bearings caused by engine lugging; the lower main bearings (not shown) were similarly affected

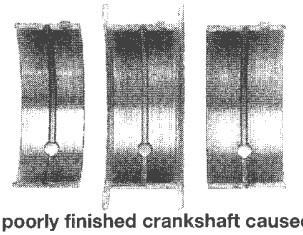


The damage shown in these upper and lower connecting rod bearings was caused by engine operation at a higher-than-rated speed under load

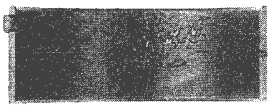
Misalignment



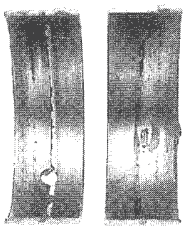
A warped crankshaft caused this pattern of severe wear in the centre, diminishing toward the ends



A poorly finished crankshaft caused the equally spaced scoring shown

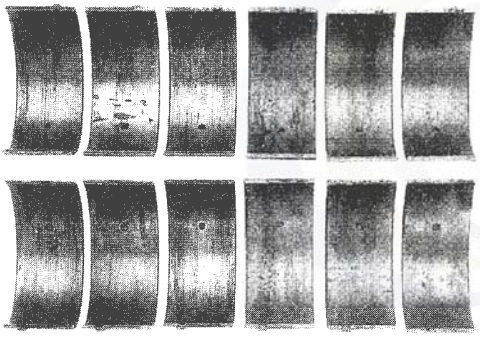


A bent connecting rod led to the damage in the "V" pattern

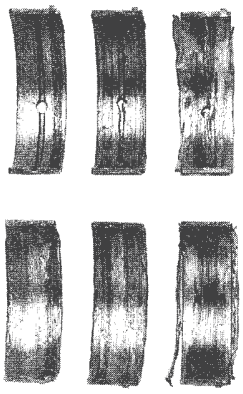


A tapered housing bore caused the damage along one edge of this pair

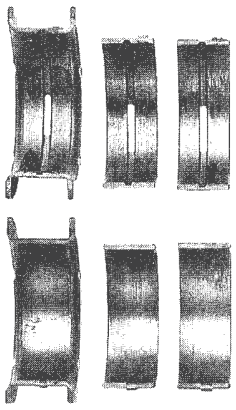
Lubrication



Result of dry start: The bearings on the left, farthest from the oil pump, show more damage



Result of a low oil supply or oil starvation



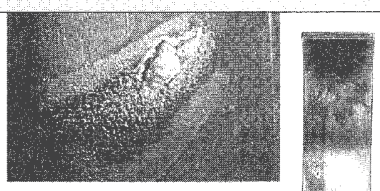
Severe wear as a result of inadequate oil clearance

Corrosion

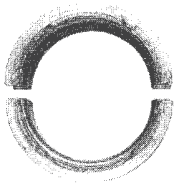
Microscopic detail of corrosion

Corrosion is an acid attack on the bearing lining generally caused by inadequate maintenance, extremely hot or cold operation, or inferior oils or fuels

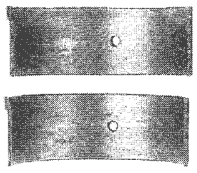
Microscopic detail of cavitation



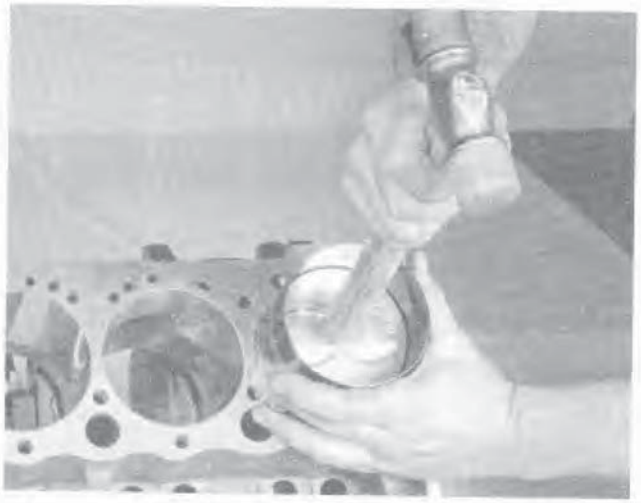
Example of cavitation - a surface erosion caused by pressure changes in the oil film



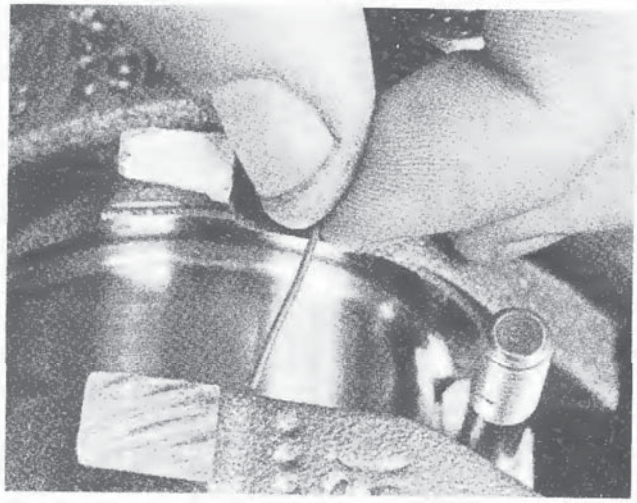
Damage from excessive thrust or insufficient axial clearance



Bearing affected by oil dilution caused by excessive blow-by or a rich mixture



27.11 Drive the piston into the cylinder bore with the end of a wooden or plastic hammer handle



27.13 Lay the Plastigage strips on each rod bearing journal, parallel to the crankshaft centreline

pistons and connecting rod assemblies can be fitted in either the right or left bank if new rods were fitted.

10 Tap the top edge of the ring compressor to make sure it's contacting the block around its entire circumference.

11 Gently tap on the top of the piston with the end of a wooden or plastic hammer handle (see illustration) while guiding the end of the connecting rod into place on the crankshaft journal. The piston rings may try to pop out of the ring compressor just before entering the cylinder bore, so keep some force down on the ring compressor. Work slowly, and if any resistance is felt as the piston enters the cylinder, stop immediately. Find out what's hanging up and fix it before proceeding. Do not, for any reason, force the piston into the cylinder - you might break a ring and/or the piston.

12 Once the piston/connecting rod assembly is refitted, the connecting rod bearing oil clearance must be checked before the rod cap is permanently bolted in place.

13 Cut a piece of the appropriate size Plastigage slightly shorter than the width of the connecting rod bearing and lay it in place on the number one connecting rod journal, parallel with the journal axis (see illustration).

14 Clean the connecting rod cap bearing face, remove the protective hoses from the connecting rod bolts and refit the rod cap. Make sure the mating mark on the cap is on the same side as the mark on the connecting rod.

15 Refit the nuts and tighten them to the torque listed in this Chapter's Specifications. Work up to it in three steps.

Note: *Use a thin-wall socket to avoid erroneous torque readings that can result if the socket is wedged between the rod cap and nut. If the socket tends to wedge itself between the nut and the cap, lift up on it slightly until it no longer contacts the cap.*

Do not rotate the crankshaft at any time during this operation.

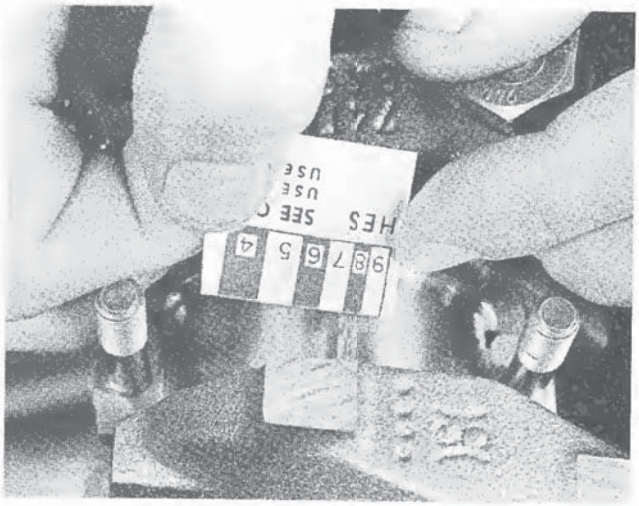
16 Remove the nuts and detach the rod cap, being very careful not to disturb the Plastigage.

17 Compare the width of the crushed Plastigage to the scale printed on the Plastigage envelope to obtain the oil clearance (see illustration). Compare it to this Chapter's Specifications to make sure the clearance is correct.

18 If the clearance is not as specified, the bearing inserts may be the wrong size (which means different ones will be required). Before deciding different inserts are needed, make sure no dirt or oil was between the bearing inserts and the connecting rod or cap when the clearance was measured. Also, recheck the journal diameter. If the Plastigage was wider at one end than the other, the journal may be tapered (see Section 20).

19 As a final step, the connecting rod endplay must be rechecked (see Section 14).

20 Compare the measured endplay to this Chapter's Specifications to make sure it's correct. If it was correct before disassembly and the original crankshaft and rods were refitted, it should still be right. If new rods or a new crankshaft were fitted, the endplay may be inadequate. If so,



27.17 Measuring the width of the crushed Plastigage to determine the rod bearing oil clearance (be sure to use the correct scale - standard and metric ones are included)

the rods will have to be removed and taken to an automotive machine shop for re-sizing.

FINAL PISTON AND CONNECTING ROD REFITTING

21 Carefully scrape all traces of the Plastigage material off the rod journal and/or bearing face. Be very careful not to scratch the bearing - use your fingernail or the edge of a credit card.

22 Make sure the bearing faces are perfectly clean, then apply a uniform layer of clean moly-base grease or engine assembly lube to both of them. You'll have to push the piston into the cylinder to expose the face of the bearing insert in the connecting rod - be sure to slip the protective hoses over the rod bolts first.

23 Slide the connecting rod back into place on the journal, remove the protective hoses from the rod cap bolts, refit the rod cap and tighten the nuts to the torque listed in this Chapter's Specifications. Again, work up to the torque in three steps.

24 Repeat the entire procedure for the remaining pistons/connecting rods.

25 The important points to remember are:

a) Keep the back sides of the bearing inserts and the insides of the connecting rods and caps perfectly clean when assembling them.
b) Make sure you have the correct piston/rod assembly for each cylinder.
c) The arrow or mark on the piston must face the front of the engine.
d) Lubricate the cylinder walls with clean oil.
e) Lubricate the bearing faces when refitting the rod caps after the oil clearance has been checked.

26 After all the piston/connecting rod assemblies have been properly refitted, rotate the crankshaft a number of times by hand to check for any obvious binding.

28 Flywheel/driveplate - removal and refitting

For flywheel/driveplate removal and refitting procedures, refer to Part A, B, C or D.

29 Initial start-up and break-in after overhaul

Warning: *Have a fire extinguisher handy when starting the engine for the first time.*

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information on at the front of this manual for the radio re-activation procedure.*

1 Once the engine has been refitted in the vehicle, double-check the oil and coolant levels.

2 With the spark plugs out of the engine, remove the PCM (F14) fuse from the instrument panel fuse block and the IGNITION (F35) fuse from the underhood fuse block. Crank the engine until oil pressure registers on the gauge or the light goes out.

3 Refit the spark plugs, hook up the plug wires and refit the fuses.

4 Start the engine. It may take a few moments for the fuel system to build up pressure, but the engine should start without a great deal of effort.

Note: *If the engine keeps backfiring, recheck the valve timing and spark plug wire routing.*

5 After the engine starts, it should be allowed to warm up to normal operating temperature. While the engine is warming up, make a thorough check for fuel, oil and coolant leaks.

6 Shut the engine off and recheck the engine oil and coolant levels.

7 Drive the vehicle to an area with no traffic, accelerate from 50 to 70 kph, then allow the vehicle to slow to 50 kph with the throttle closed. Repeat the procedure 10 or 12 times. This will load the piston rings and cause them to seat properly against the cylinder walls. Check again for oil and coolant leaks.

8 Drive the vehicle gently for the first 800 kilometres (no sustained high speeds) and keep a constant check on the oil level. It isn't unusual for an engine to use oil during the break-in period.

9 At approximately 1,000 kilometres, change the oil and filter.

10 For the next few hundred kilometres, drive the vehicle normally. Don't pamper it or abuse it.

11 After 2000 kilometres, change the oil and filter again and consider the engine broken in.

COMMON ENGINE OVERHAUL TERMS

B

Backlash - The amount of play between two parts. Usually refers to how much one gear can be moved back and forth without moving gear with which it's meshed.

Bearing Caps - The caps held in place by nuts or bolts which, in turn, hold the bearing surface. This space is for lubricating oil to enter.

Bearing clearance - The amount of space left between shaft and bearing surface. This space is for lubricating oil to enter.

Bearing crush - The additional height which is purposely manufactured into each bearing half to ensure complete contact of the bearing back with the housing bore when the engine is assembled.

Bearing knock - The noise created by movement of a part in a loose or worn bearing.

Blueprinting - Dismantling an engine and reassembling it to EXACT specifications.

Bore - An engine cylinder, or any cylindrical hole; also used to describe the process of enlarging or accurately refinishing a hole with a cutting tool, as to bore an engine cylinder. The bore size is the diameter of the hole.

Boring - Renewing the cylinders by cutting them out to a specified size. A boring bar is used to make the cut.

Bottom end - A term which refers collectively to the engine block, crankshaft, main bearings and the big ends of the connecting rods.

Break-in - The period of operation between installation of new or rebuilt parts and time in which parts are worn to the correct fit. Driving at reduced and varying speed for a specified mileage to permit parts to wear to the correct fit.

Bushing - A one-piece sleeve placed in a bore to serve as a bearing surface for shaft, piston pin, etc. Usually replaceable.

C

Camshaft - The shaft in the engine, on which a series of lobes are located for operating the valve mechanisms. The camshaft is driven by gears or sprockets and a timing chain. Usually referred to simply as the cam.

Carbon - Hard, or soft, black deposits found in combustion chamber, on plugs, under rings, on and under valve heads.

Cast iron - An alloy of iron and more than two percent carbon, used for engine blocks and heads because it's relatively inexpensive and easy to mold into complex shapes.

Chamfer - To bevel across (or a bevel on) the sharp edge of an object.

Chase - To repair damaged threads with a tap or die.

Combustion chamber - The space between the piston and the cylinder head, with the piston at top dead centre, in which air-fuel mixture is burned.

Compression ratio - The relationship between cylinder volume (clearance volume) when the piston is at top dead centre and cylinder volume when the piston is at bottom dead center.

Connecting rod - The rod that connects the crank on the crankshaft with the piston. Sometimes called a con rod.

Connecting rod cap - The part of the connecting rod assembly that attaches the rod to the crankpin.

Core plug - Soft metal plug used to plug the casting holes for the coolant passages in the block.

Crankcase - The lower part of the engine in which the crankshaft rotates; includes the lower section of the cylinder block and the oil pan.

Crank kit - A reground or reconditioned crankshaft and new main and connecting rod bearings.

Crankpin - The part of a crankshaft to which a connecting rod is attached.

Crankshaft - The main rotating member, or shaft, running the length of the crankcase, with offset throws to which the connecting rods are attached; changes the reciprocating motion of the pistons into rotating motion.

Cylinder sleeve - A replaceable sleeve, or liner, pressed into the cylinder block to form the cylinder bore.

D

Deburring - Removing the burrs (rough edges or areas) from a bearing.

Deglazer - A tool, rotated by an electric motor, used to remove glaze from cylinder walls so a new set of rings will seat.

E

Endplay - The amount of lengthwise movement between two parts. As applied to a crankshaft, the distance that the crankshaft can move forward and back in the cylinder block.

F

Face - A machinist's term that refers to removing metal from the end of a shaft or the face of a larger part, such as a flywheel.

Fatigue - A breakdown of material through a large number of loading and unloading cycles. The first signs are cracks followed shortly by breaks.

Feeler gauge - A thin strip of hardened steel, ground to an exact thickness, used to check clearances between parts.

Free height - The unloaded length or height of a spring.

Freeplay - The looseness in a linkage, or an assembly of parts, between the initial application of force and actual movement. Usually perceived as slop or slight delay.

Freeze plug - See Core plug.

G

Gallery - A large passage in the block that forms a reservoir for engine oil pressure.

Glaze - The very smooth, glassy finish that develops on cylinder walls while an engine is in service.

H

Heli-Coil - A rethreading device used when threads are worn or damaged. The device is fitted in a retapped hole to reduce the thread size to the original size.

I

Installed height - The spring's measured length or height, as installed on the cylinder head. Installed height is measured from the spring seat to the underside of the spring retainer.

J

Journal - The surface of a rotating shaft which turns in a bearing.

K

Keeper - The split lock that holds the valve spring retainer in position on the valve stem.

Key - A small piece of metal inserted into matching grooves machined into two parts fitted together - such as a gear pressed onto a shaft - which prevents slippage between the two parts.

Knock - The heavy metallic engine sound, produced in the combustion chamber as a result of abnormal combustion - usually detonation. Knock is usually caused by a loose or worn bearing. Also referred to as detonation, pinging and spark knock. Connecting rod or main bearing knocks are created by too much oil clearance or insufficient lubrication.

L

Lands - The portions of metal between the piston ring grooves.

Lapping the valves - Grinding a valve face and its seat together with lapping compound.

Lash - The amount of free motion in a gear train, between gears, or in a mechanical assembly, that occurs before movement can

begin. Usually refers to the lash in a valve train.

Lifter - The part that rides against the cam to transfer motion to the rest of the valve train.

M

Machining - The process of using a machine to remove metal from a metal part.

Main bearings - The plain, or babbit, bearings that support the crankshaft.

Main bearing caps - The cast iron caps, bolted to the bottom of the block, that support the main bearings.

O

O.D. - Outside diameter.

Oil gallery - A pipe or drilled passageway in the engine used to carry engine oil from one area to another.

Oil ring - The lower ring, or rings, of a piston; designed to prevent excessive amounts of oil from working up the cylinder walls and into the combustion chamber. Also called an oil-control ring.

Oil seal - A seal which keeps oil from leaking out of a compartment. Usually refers to a dynamic seal around a rotating shaft or other moving part.

O-ring - A type of sealing ring made of a special rubberlike material; in use, the O-ring is compressed into a groove to provide the sealing action.

Overhaul - To completely disassemble a unit, clean and inspect all parts, reassemble it with the original or new parts and make all adjustments necessary for proper operation.

P

Pilot bearing - A small bearing installed in the center of the flywheel (or the rear end of the crankshaft) to support the front end of the input shaft of the transmission.

Pip mark - A little dot or indentation which indicates the top side of a compression ring.

Piston - The cylindrical part, attached to the connecting rod, that moves up and down in the cylinder as the crankshaft rotates. When the fuel charge is fired, the piston transfers the force of the explosion to the connecting rod, then to the crankshaft.

Piston pin (or wrist pin) - The cylindrical and usually hollow steel pin that passes through the piston. The piston pin fastens the piston to the upper end of the connecting rod.

Piston ring - The split ring fitted to the groove in a piston. The ring contacts the sides of the ring groove and also rubs against the cylinder wall, thus sealing space between piston and wall. There are two types of rings: Compression rings seal the compression pressure in the combustion chamber; oil rings scrape excessive oil off the cylinder wall.

Piston ring groove - The slots or grooves cut in piston heads to hold piston rings in position.

Piston skirt - The portion of the piston below the rings and the piston pin hole.

Plastigage - A thin strip of plastic thread, available in different sizes, used for measuring clearances. For example, a strip of plastigage is laid across a bearing journal and mashed as parts are assembled. Then parts are disassembled and the width of the strip is measured to determine clearance between journal and bearing. Commonly used to measure crankshaft main-bearing and connecting rod bearing clearances.

Press-fit - A tight fit between two parts that requires pressure to force the parts together. Also referred to as drive, or force, fit.

Prussian blue - A blue pigment; in solution, useful in determining the area of contact between two surfaces. Prussian blue is commonly used to determine the width and location of the contact area between the valve face and the valve seat.

R

Race (bearing) - The inner or outer ring that provides a contact surface for balls or rollers in bearing.

Ream - To size, enlarge or smooth a hole by using a round cutting tool with fluted edges.

Ring job - The process of reconditioning the cylinders and installing new rings.

Runout - Wobble. The amount a shaft rotates out-of-true.

S

Saddle - The upper main bearing seat.

Scored - Scratched or grooved, as a cylinder wall may be scored by abrasive particles moved up and down by the piston rings.

Scuffing - A type of wear in which there's a transfer of material between parts moving against each other; shows up as pits or grooves in the mating surfaces.

Seat - The surface upon which another part rests or seats. For example, the valve seat is the matched surface upon which the valve face rests. Also used to refer to wearing into a good fit; for example, piston rings seat after a few miles of driving.

Short block - An engine block complete with crankshaft and piston and, usually, camshaft assemblies.

Static balance - The balance of an object while it's stationary.

Step - The wear on the lower portion of a ring land caused by excessive side and back-clearance. The height of the step indicates the ring's extra side clearance and the length of the step projecting from the back wall of the groove represents the ring's back clearance.

Stroke - The distance the piston moves when traveling from top dead centre to bottom dead centre, or from bottom dead centre to top dead center.

Stud - A metal rod with threads on both ends.

T

Tang - A lip on the end of a plain bearing used to align the bearing during assembly.

Tap - To cut threads in a hole. Also refers to the fluted tool used to cut threads.

Taper - A gradual reduction in the width of a shaft or hole; in an engine cylinder, taper usually takes the form of uneven wear, more pronounced at the top than at the bottom.

Throws - The offset portions of the crankshaft to which the connecting rods are affixed.

Thrust bearing - The main bearing that has thrust faces to prevent excessive endplay, or forward and backward movement of the crankshaft.

Thrust washer - A bronze or hardened steel washer placed between two moving parts. The washer prevents longitudinal movement and provides a bearing surface for thrust surfaces of parts.

Tolerance - The amount of variation permitted from an exact size of measurement. Actual amount from smallest acceptable dimension to largest acceptable dimension.

U

Umbrella - An oil deflector placed near the valve tip to throw oil from the valve stem area.

Undercut - A machined groove below the normal surface.

Undersize bearings - Smaller diameter bearings used with re-ground crankshaft journals.

V

Valve grinding - Refacing a valve in a valve-refacing machine.

Valve train - The valve-operating mechanism of an engine; includes all components from the camshaft to the valve.

Vibration damper - A cylindrical weight attached to the front of the crankshaft to minimize torsional vibration (the twist-untwist actions of the crankshaft caused by the cylinder firing impulses). Also called a harmonic balancer.

W

Water jacket - The spaces around the cylinders, between the inner and outer shells of the cylinder block or head, through which coolant circulates.

Web - A supporting structure across a cavity.

Woodruff key - A key with a radiused backside (viewed from the side).

Notes

Chapter 3

Cooling, heating and air conditioning systems

Contents

Specifications

General

Coolant capacity	See Chapter 1
Drivebelt tension	See Chapter 1
Radiator pressure cap rating	
V6 models	
3.8 litre	135 kPa
3.6 litre	120 kPa
V8 models	
5.0 litre	100 kPa
5.7 litre and 6.0 litre	120 kPa
Thermostat opening temperature	
3.8 litre V6 and 5.0 litre V8 models	89 to 93 degrees C
3.6 litre V6 models	82 to 95 degrees C
5.7 litre Gen III V8 and 6.0 litre Gen IV models	86 to 100 degrees C

Torque specifications

	Nm
Thermostat housing bolts	
V6 models	
3.8 litre	20 to 34
3.6 litre	10
V8 models	
5.0 litre	20 to 27
5.7 litre Gen III and 6.0 litre Gen IV	13 to 15
Water pump to block bolts	
3.8 litre V6 and 5.0 litre V8 models	20 to 30
5.7 litre Gen III and 6.0 litre Gen IV	
Step one	15
Step two	25
Water pump to front cover bolts	
3.8 litre V6 and 5.0 litre V8 models	14 to 18
3.6 litre V6 models	10
Water pump pulley bolts	
3.8 litre V6 and 5.0 litre V8 models	10 to 16
3.6 litre V6 models	12
Water pump rear cover bolts	
5.7 litre Gen III and 6.0 litre Gen IV	14

1 General information

The cooling system on all models consists of a radiator and coolant reserve system, a radiator pressure cap, a thermostat, one or two electric fans and a water pump. The water pump has a pulley that is driven by a serpentine belt (V6 models) or V-belts (V8 models).

The cooling fans are mounted on the engine-side of the radiator and are controlled by the PCM (powertrain control module) and a fan relay.

The system is pressurised by a spring-loaded radiator cap, which, by maintaining pressure, increases the boiling point of the coolant. If the coolant temperature goes above this increased boiling point, the extra pressure in the system forces the radiator cap valve off its seat and exposes the overflow pipe or hose. The overflow pipe/hose leads to a coolant recovery system. This consists of a plastic reservoir into which the coolant that normally escapes due to expansion is retained. When the engine cools, the excess coolant is drawn back into the radiator by the vacuum created as the system cools, maintaining the system at full capacity. This is a continuous process and provided the level in the reservoir is correctly maintained, it is not necessary to add coolant to the radiator.

Coolant in the tank of the radiator is drawn by the water pump, which forces it through the water passages in the cylinder block. The coolant then travels up into the cylinder head, circulates around the combustion chambers and valve seats, travels out of the cylinder head past the open thermostat into the upper radiator hose and back into the radiator.

When the engine is cold, the thermostat restricts the circulation of coolant to the engine. When the minimum operating temperature is reached, the thermostat begins to open, allowing coolant to return to the radiator.

Automatic transmission-equipped models have a cooler element incorporated into the tank of the radiator to cool the transmission fluid.

The heating system works by directing air through the heater core mounted in the dash and to the interior of the vehicle by a system of ducts. Temperature is controlled by mixing heated air with fresh air, using a system of doors in the ducts, and a blower motor.

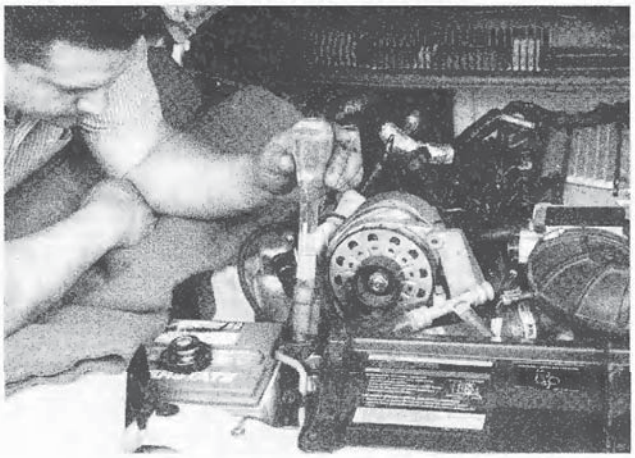
Air conditioning is an optional accessory, consisting of an evaporator core located under the dash, a condenser in front of the radiator, a receiver-drier in the engine compartment and a belt-driven compressor mounted at the front of the engine.

2 Antifreeze - general information

Refer to illustration 2.4

***Warning:** Do not allow antifreeze to come in contact with your skin or painted surfaces of the vehicle. Rinse off spills immediately with plenty of water. Antifreeze is highly toxic if ingested. Never leave antifreeze lying around in an open container or in puddles on the floor; children and pets are attracted by it's sweet smell and may drink it. Check with local authorities about disposing of used antifreeze. Many communities have collection centres which will see that antifreeze is disposed of safely. Never dump used antifreeze on the ground or pour it into drains.*

***Note:** Non-toxic antifreeze is now available at most auto parts stores, but even these types should be disposed of properly.*



2.4 An inexpensive hydrometer can be used to test the condition of your coolant

1 The cooling system should be filled with a water/ethylene glycol based antifreeze solution which will prevent freezing down to at least -30-degrees C (even lower in cold climates). It also provides protection against corrosion and increases the coolant boiling point.

2 The cooling system should be drained, flushed and refilled at least every other year (see Chapter 1). The use of antifreeze solutions for periods of longer than two years is likely to cause damage and encourage the formation of rust and scale in the system.

3 Before adding antifreeze to the system, check all hose connections. Antifreeze can leak through very minute openings.

4 The exact mixture of antifreeze to water which you should use depends on the relative weather conditions. The mixture should contain at least 30-percent antifreeze, but should never contain more than 70-percent antifreeze. Consult the mixture ratio chart on the antifreeze container before adding coolant. Hydrometers are available at most auto parts stores to test the coolant (see illustration). Use antifreeze which meets the vehicle manufacturer's specifications.

3 Thermostat - check and renewal

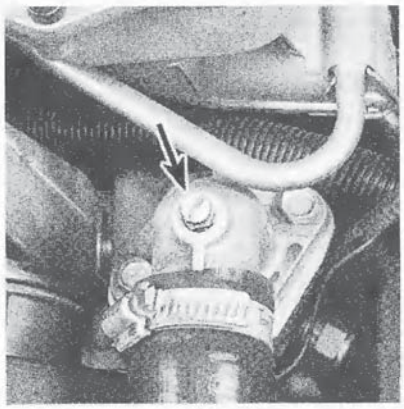
***Warning:** The engine must be completely cool when this procedure is performed.*

***Note 1:** Don't drive the vehicle without a thermostat! The computer may stay in open loop mode and emissions, engine life and fuel economy will suffer.*

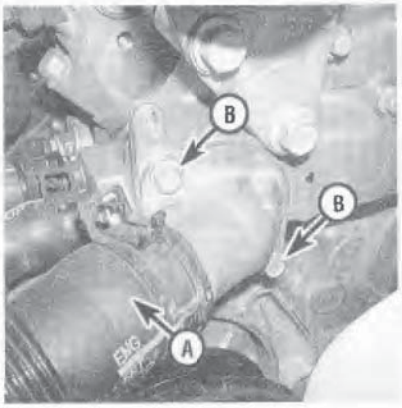
***Note 2:** V6 supercharged engines use a modified cooling system with the thermostat located at the rear of the engine rather than the front. On these engines, coolant passes through a long tube on the right side of the engine after it exits the thermostat housing.*

CHECK

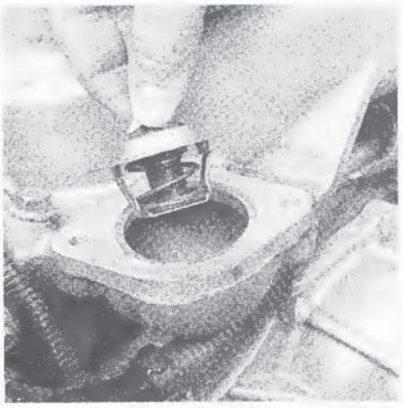
1 Before condemning the thermostat, check the coolant level, drivebelt tension and temperature gauge (or light) operation.



3.10a The thermostat housing is retained by two bolts. On some models there is an air bleed fitting on its top (arrow) - non-supercharged V6 engine shown



3.10b On 5.7 litre Gen III V8 engines, remove the lower radiator hose (A) and the thermostat housing bolts (B)



3.11 Note how it is refitted, then remove the thermostat (the spring end points towards the engine)

2 If the engine takes a long time to warm up, the thermostat is probably stuck open. Renew the thermostat.

3 If the engine runs hot, check the temperature of the upper radiator hose. If the hose isn't hot, the thermostat is probably stuck shut. Renew the thermostat.

4 If the upper radiator hose is hot, it means the coolant is circulating and the thermostat is open. Refer to the Troubleshooting section for the cause of overheating.

5 If an engine has been overheated, you may find damage such as leaking head gaskets, scuffed pistons and warped or cracked cylinder heads.

RENEWAL - EXCEPT 3.6L V6 MODELS

Refer to illustrations 3.10a, 3.10b and 3.11

6 Drain the coolant (about 4 litres) from the radiator, until the coolant level is below the thermostat housing (refer to Chapter 1).

7 Remove the engine cover. On supercharged models, remove the long bracket from the top of the rear of the supercharger, then remove the vacuum line assembly from beneath it.

8 On supercharged models only, remove the bolts securing the bypass valve actuator and rotate it to provide clearance to the thermostat housing bolts. Also remove the air inlet duct, the throttle body and the throttle cable bracket (refer to Chapter 4).

9 Disconnect the radiator hose from the thermostat cover.

> ***Note:*** *Some models do not have a thermostat housing gasket. It isn't necessary to remove the hose unless it is being renewed, except on supercharged V6 models.*

10 Remove the bolt(s) and lift the thermostat housing off (see illustrations). It may be necessary to tap it with a soft-face hammer to break the gasket seal.

11 Note how it's refitted, then remove the thermostat (see illustration). Be sure to use a thermostat with the correct opening temperature (see this Chapter's Specifications).

> ***Note:*** *On Generation III and Generation IV V8 engines, the thermostat is removed by pushing the thermostat into the housing and rotating the thermostat anti-clockwise to disconnect the thermostat from the housing (see illustration).*

12 If a gasket was used, use a scraper or putty knife to remove all traces of old gasket material and sealant from the mating surfaces.

> ***Caution:*** *Be careful not to gouge or damage the gasket surfaces, because a leak could develop after assembly. Make sure no gasket material falls into the coolant passage; it's a good idea to stuff a rag in the passage. Wipe the mating surfaces with a rag saturated with lacquer thinner or acetone.*

13 Refit the thermostat and make sure the correct end faces out - the spring is directed toward the engine.

14 Some models will not have a traditional gasket, but rather a rubber ring around the thermostat. If so, renew this ring and refit the thermostat cover without gasket sealant.

> ***Note:*** *If a gasket was used, apply a thin coat of RTV sealant to both sides of the new gasket and position it on the engine side, over the thermostat, and make sure the gasket holes line up with the bolt holes in the housing.*

15 Carefully position the cover and refit the bolts. Tighten them to the torque listed in this Chapter's Specifications - do not over-tighten the bolts or the cover may crack or become distorted.

16 Reattach the radiator hose to the cover and tighten the clamp - now may be a good time to check and renew the hoses and clamps (see Chapter 1). Refit components removed previously.

17 Refer to Chapter 1 and refill the system, then run the engine and check carefully for leaks.

18 Repeat Steps 1 through 5 to be sure the repairs corrected the previous problem(s).

RENEWAL - 3.6L V6 MODELS

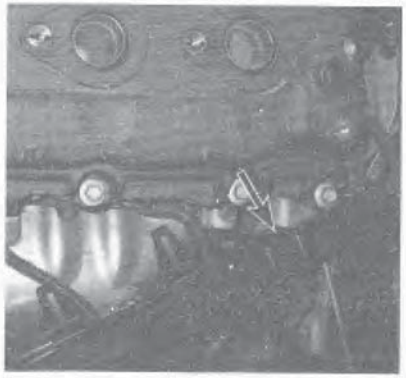
Refer to illustrations 3.23, 3.25 and 3.26

19 Drain coolant from the cooling system (refer to Chapter 1).

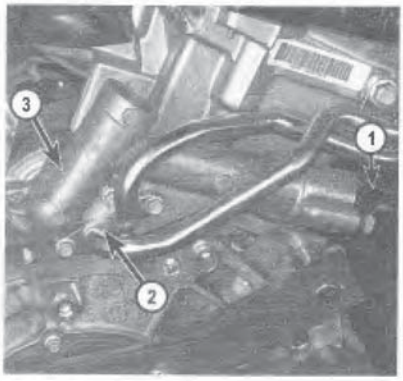
20 Remove the upper radiator shroud from the vehicle.

21 Remove the engine dress cover, plenum and inlet manifold (refer to Chapter 2B, Section 7).

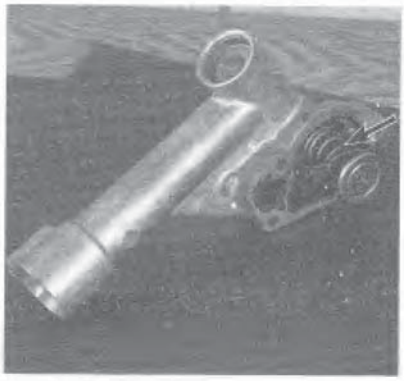
22 Remove the lower radiator hose from the coolant pipe. Remove the bolts retaining the coolant pipe to the engine



3.23 Move the wiring harness to the other side of the engine to gain easier access to the thermostat housing



3.25 Thermostat housing components
1 *Coolant pipe*
2 *Heater pipe flange*
3 *Thermostat housing*



3.26 Thermostat (arrow) inside the housing

and thermostat housing and disconnect the coolant pipe from the housing. Discard the O-ring.

23 Using a flat-bladed screwdriver, disconnect the heater hose quick connectors from the heater pipes. To make access to the thermostat housing easier, disconnect the wiring from the LH side of the engine (see illustration) and move the harness over to the RH side of the engine clear of the work area.

24 Remove the bolt holding the heater pipes to the cylinder head and the bolts holding the heater pipe flanges and slide the heater pipes from the thermostat housing. Discard the O-rings.

25 Remove the bolt(s) and lift the thermostat housing off (see illustrations). It may be necessary to tap it with a soft-face hammer to break the gasket seal.

26 To remove the thermostat from the housing, push the thermostat into the housing and rotate the thermostat anti-clockwise to disconnect the thermostat from the housing (see illustration). Be sure to use a thermostat with the correct opening temperature (see this Chapter's Specifications).

27 Use a scraper or putty knife to remove all traces of old gasket material and sealant from the mating surfaces.

Caution: *Be careful not to gouge or damage the gasket surfaces, because a leak could develop after assembly. Make sure no gasket material falls into the coolant passage; it's a good idea to stuff a rag in the passage. Wipe the mating surfaces with a rag saturated with lacquer thinner or acetone.*

28 Refit the thermostat to the housing.

Note: *At the time of publication, a new thermostat was only supplied as an assembly installed to the thermostat housing.*

29 Apply a thin coat of RTV sealant to both sides of the new gasket and position it on the engine side, over the thermostat, and make sure the gasket holes line up with the bolt holes in the housing.

30 Carefully position the cover and refit the bolts. Tighten them to the torque listed in this Chapter's Specifications - do not over-tighten the bolts or the cover may crack or become distorted.

31 Reattach the heater pipe and coolant pipe to the thermostat housing using new O-rings. Install the coolant pipe retaining bolts and the lower radiator hose and tighten the clamp - now may be a good time to check and renew the hoses and clamps (see Chapter 1). Refit components removed previously.

32 Refer to Chapter 1 and refill the system, then run the engine and check carefully for leaks.

33 Repeat Steps 1 through 5 to be sure the repairs corrected the previous problem(s).

4 Electric engine cooling fans and circuit - check, removal and refitting

Warning: *Keep hands, tools and clothing away from the fan. To avoid injury or damage DO NOT operate the engine with a damaged fan. Do not attempt to repair fan blades - renew a damaged fan.*

Note: *Most models have two electric engine cooling fans. The following procedures apply to both fans.*

CHECK

Refer to illustrations 4.1a, 4.1b and 4.2

1 To test a fan motor, unplug the electrical connector at the motor (see illustrations) and use fused jumper wires to connect the fan directly to the battery. If the fan still does not work, renew the motor.

2 If the motor tests OK, check the cooling fan relays, located in the underbonnet fuse/relay panel (see illustration).

3 Check the fan fuse with a test light. It is located in the fuse box.

4 If the fan runs all the time, check the relay. It may be stuck closed.

5 If the relays check out and the fan motor works, check the circuit back to the PCM (computer).

6 If the circuit checks OK but the fan(s) still don't come on, check the engine coolant temperature sensor.

RENEWAL

Refer to illustrations 4.8, 4.10, 4.11 and 4.12

7 Disconnect the cable from the negative terminal of the battery.

4.1a Locations of the fan connectors (arrows) on twin cooling fan applications

4.1b Disconnect the electrical connector from the fan and apply fused battery power and earth to test it

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

8 Where fitted, remove the upper radiator shroud from the vehicle and then disconnect the wiring harness to the electric fans (see illustration).

9 Remove the power steering pump reservoir for access if necessary and position clear of the work area.

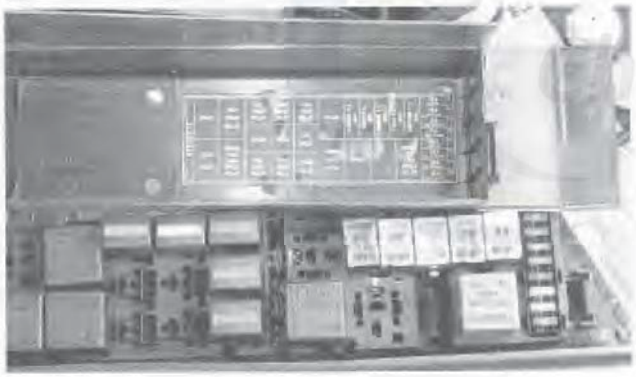
Note: *Do not disconnect the fluid lines.*

10 Remove the shroud mounting bolts. Lift the fan and shroud assembly out (see illustration).

11 To detach the fan from the motor, remove the motor shaft nut (see illustration).

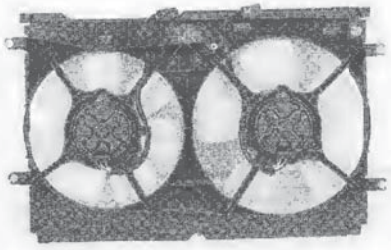
12 To detach the fan motor from its mount, remove the screws (see illustration).

13 Refitting is the reverse of removal.



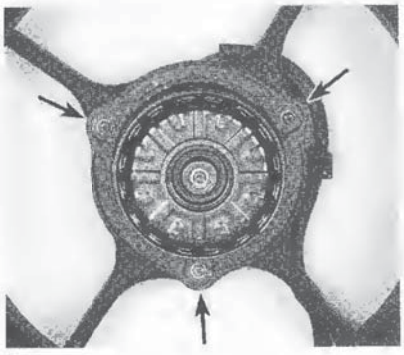
4.2 The relay for the engine cooling fans is located in the relay centre in the engine compartment

4.8 Disconnect the engine cooling fan wiring harness at this point



4.10 The complete fan and shroud unit can be removed from the vehicle. This will make it easy to remove the motor or the blade

4.11 Remove this nut to take off the fan



4.12 The fan motor is removed from the shroud by removing these screws

5 Radiator and coolant reservoir - removal and refitting

Warning: *The engine must be completely cool when this procedure is performed.*

Note: *Some models have quick release type A/T cooler hose connections that connect the transmission cooler hoses to the automatic transmission. A special tool is required to disconnect these hoses and the part number is AU525. However, a tool can be manufactured from a round plastic sleeve sliced lengthways into two halves that has an inside diameter similar to the diameter of the cooler pipe. This can be constructed from a biro lid or similar and is slid over the pipe and pushed into the connector while pushing the hose toward the pipe. Once the connector is released the hose can be pulled from the pipe.*

RADIATOR

Removal

Refer to illustrations 5.2, 5.9a, 5.9b and 5.10

1 Disconnect the cable from the negative terminal of the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 If necessary remove the air inlet duct from above the radiator shroud that goes to the air filter intake. Remove the upper radiator shroud (see illustration) from the vehicle and then drain the cooling system by disconnecting the lower radiator hose as described in Chapter 1. Refer to the coolant warning in Section 2 of this chapter. It is not necessary to drain the engine block.

3 Disconnect the upper radiator hose from the radiator, and disconnect the small hose at the radiator neck.

4 Disconnect any automatic transmission cooling lines and plug both ends of them.

Note: *On models with quick release type connections, use the manufacturer a special tool or use the tool specified to release the hoses from the pipes. Suitably mark each hose so they are returned to the correct pipe.*

5.2 The upper shroud is secured by these retainers. Note air inlet duct is still in place in this photo

5 Remove the power steering pump reservoir for access if necessary and position clear of the work area.

Note: *Do not disconnect the power steering fluid lines.*

6 On VZ models, remove the front grille (see Chapter 11).

7 On VZ models, reach down in front of the radiator and press the clips retaining the air conditioning condenser to the radiator side tank on both sides of the condenser down. This will unlock the condenser from the radiator. Pull the condenser/receiver drier and pipes forward until the condenser is clear of the locating lugs in the radiator side tanks.

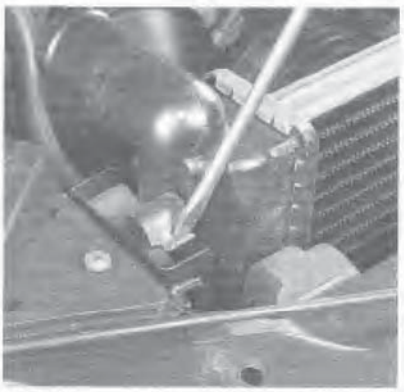
Note: *Do not disconnect the A/C refrigerant lines. The condenser can be moved forward enough with the refrigerant lines still connected.*

8 Disconnect the wiring to the electric fans and remove the cooling fans from the vehicle.

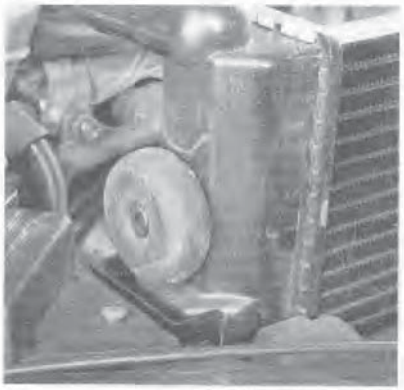
9 Use a screwdriver to remove the clips which secure the upper sides of the radiator to its support (see illustrations).

10 Lift the radiator out (see illustration).

5.9a Use a screwdriver to remove the radiator side clips. Press downward to release the clip



5.9b This view shows the radiator retaining clip disengaged



5.10 Carefully lift the radiator from the support to avoid damaging the fins. Round rubber bumpers are located at each side of the radiator

Refitting

11 Prior to refitting of the radiator, renew any damaged hose clamps and radiator hoses.

12 If leaks have been noticed or there have been cooling problems, have the radiator cleaned and tested at a radiator shop.

13 Radiator refitting is the reverse of removal.

14 After refitting, fill the system with the proper mixture of antifreeze, bleed the air from the cooling system as described in Chapter 1, and also check the automatic transmission fluid level, where applicable (see Chapter 1).

COOLANT RESERVOIR

Removal and refitting

15 Remove the hoses from the radiator and the reservoir.

16 Remove the screws, then lift out the reservoir.

17 Prior to refitting make sure the reservoir is clean and free of debris which could be drawn into the radiator (wash it with soapy water and a brush if necessary, then rinse thoroughly).

18 Refitting is the reverse of removal.

6 Water pump - check

Refer to illustration 6.2

1 Water pump failure can cause overheating and serious damage to the engine. There are three ways to check the operation of the water pump while it is refitted on the engine. If any one of the following quick-checks indicates water pump problems, it should be renewed immediately.

2 A seal protects the water pump impeller shaft bearing from contamination by engine coolant. If this seal fails, a weep hole in the water pump snout will leak coolant (see illustration) (an inspection mirror can be used to look at the underside of the pump if the hole isn't on top). If the weep hole is leaking, shaft bearing failure will follow. Renew the water pump immediately.

3 Besides contamination by coolant after a seal failure, the water pump impeller shaft bearing can also be prematurely worn out. When the bearing wears out, it emits a high-pitched squealing sound. If such a noise is coming from the water pump during engine operation, the shaft bearing has failed - renew the water pump immediately.

Note: *Do not confuse belt noise with bearing noise.*

4 To identify excessive bearing wear on water pumps, grasp the water pump pulley and try to force it up-and-down or from side-to-side. If the pulley can be moved either horizontally or vertically, the bearing is nearing the end of its service life. Renew the water pump. Don't mistake drivebelt slippage, which causes a squealing sound, for water pump bearing failure.

5 It is possible for a water pump to be bad, even if it doesn't howl or leak water. Sometimes the fins on the back of the impeller can corrode away until the pump is no longer effective. The only way to check for this is to remove the pump for examination. The impeller can also loosen and slip on the shaft.

7 Water pump - removal and refitting

Warning: *Wait until the engine is completely cool before starting this procedure.*

REMOVAL

Refer to illustrations 7.5, 7.7, 7.10a and 7.10b

1 Disconnect the cable from the negative terminal of the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

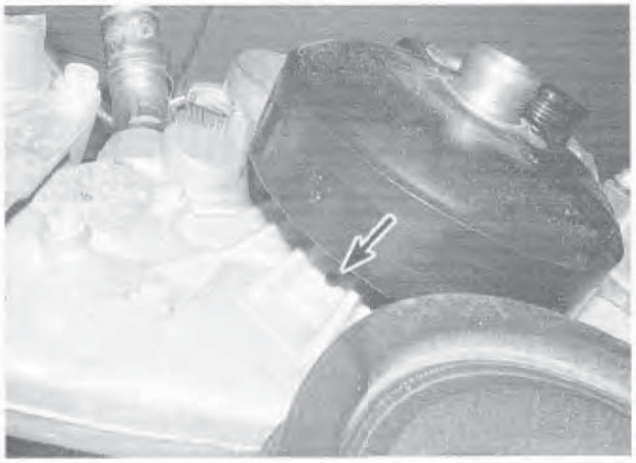
2 Drain the coolant (see Chapter 1).

V6 models

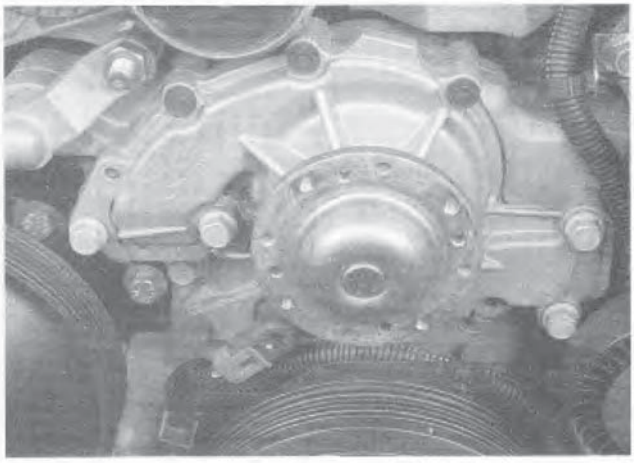
3 Loosen the water pump pulley bolts, then remove the serpentine drivebelt (see Chapter 1).

4 Detach the coolant hoses from the water pump.

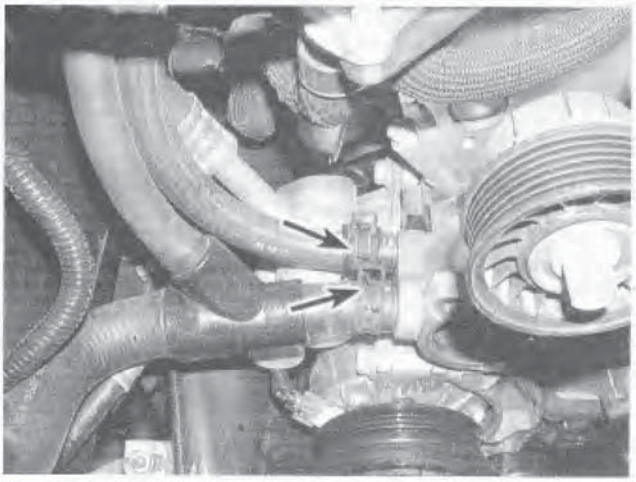
5 Remove the water pump pulley and unbolt the water pump (see illustration). It may be necessary to tap the pump with



6.2 The weep hole (arrow) is located on the bottom of the water pump (V8 engine shown, V6 similar)



7.5 Remove all bolts securing the water pump to the engine. It may be necessary to tap the water pump with a soft-face hammer to break the gasket seal prior to removing it (V6 engine shown)



7.7 Heater hose-to-water pump housing connections - 5.7 litre Gen III V8 shown

a soft-face hammer to break the gasket seal. Inspect the impeller blades on the rear of the pump for corrosion. If any blades are missing or badly corroded, renew the pump.

V8 models

6 Remove the engine trim covers.

7 Disconnect all of the hoses from the water pump (see illustration). Secure them out of the way.

8 Remove the water pump drivebelt (refer to Chapter 1).

9 Remove the water pump pulley.

10 Unbolt and remove the water pump (see illustrations). It may be necessary to tap the pump with a soft-face hammer to break the gasket seal.

REFITTING

11 Clean the sealing surfaces of all gasket material on both the water pump, spacer plate (if used) and block. Wipe the mating surfaces with a rag saturated with lacquer thinner or acetone.

12 Apply a thin layer of RTV sealant to both sides of the new gasket and fit the gasket on the water pump.

13 Place the water pump (and spacer plate, if used) in position and refit the bolts finger tight. Use caution to ensure that the gasket doesn't slip out of position. Remember to refit any mounting brackets secured by the water pump mounting bolts/studs. Tighten the bolts to the torque listed in this Chapter's Specifications.

Note: *There are different bolt torque specifications for the water pump bolts on some models.*

14 The remainder of the refitting procedure is the reverse of removal.

15 Add coolant to the specified level (see Chapter 1) and start the engine and check for the proper coolant level and the water pump and hoses for leaks. Bleed the cooling system of air as described in Chapter 1.

8 Coolant temperature sensor - check and renewal

Refer to illustration 8.1

Warning: *Wait until the engine is completely cool before beginning this procedure.*

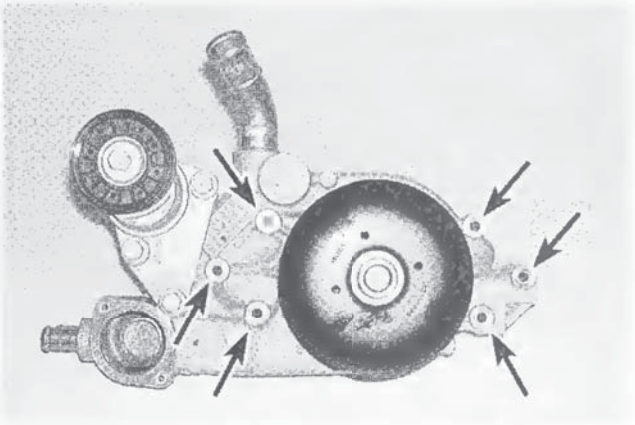
CHECK

1 The coolant temperature indicator system is composed of a temperature gauge mounted in the dash and a coolant temperature sensor mounted on the engine (see illustration). The sensor is used for the indicator system and to send temperature information to the PCM.

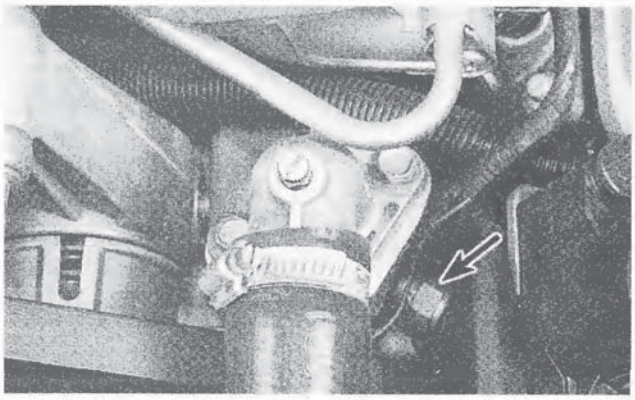
Note: *On 5.0 litre V8 and 3.8 litre V6 engines, the sensor is located at the front of the inlet manifold above the water pump. On other models, the sensor is located on the left front cylinder head above the exhaust manifold.*

2 If an overheating indication occurs, check the coolant level in the system and make sure the wiring between the gauge and the sensor is secure and all fuses/relays are intact.

7.10a The water pump on 5.0 litre V8 engines has additional hoses and brackets which must be removed prior to unbolting the pump from the engine



7.10b Water pump mounting bolt locations (arrows) - 5.7 litre Gen III V8 engines



8.1 The engine management coolant temperature sensor uses two wires (arrow). The gauge sender unit uses only one wire and is just to the left

3 Check the circuit and gauge operation by grounding the wire to the sensor while the ignition is On (engine NOT running). If the gauge deflects full scale, the circuit and gauge are OK. The problem lies in the sensor.

4 To confirm the sensor is defective, check the resistance of the unit when the engine is cold (38 degrees C or lower). Resistance should be high. Next, run the engine until it is fully warmed up and check the resistance of the sensor again. The resistance should now be low. If it doesn't respond, is shorted or open, renew the sensor.

RENEWAL

5 Make sure the engine is cool before removing the defective sensor. There will be some coolant loss as the sensor is removed, so be prepared to catch it. Refer to the coolant **Warning** in Section 2.

6 Prepare the new sensor by wrapping the threads with Teflon tape or by coating them with sealant. Disconnect the electrical connector and unscrew the sensor. Fit the new sensor as quickly as possible to minimize coolant loss.

7 Check the coolant level after the unit has been fitted and top up the system, if necessary (see Chapter 1). Check for proper operation of the gauge and sensor.

9 Blower motor and circuit - check

Refer to illustrations 9.6 and 9.8

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

1 Check the fuse (marked HVAC) and all connections in the circuit for looseness and corrosion. Make sure the battery is fully charged.

2 With the transmission in Park and the parking brake securely set, turn the ignition switch to the Run position. It isn't necessary to start the vehicle.

3 Remove the lower dash panel (below the glove box) for access to the blower motor.

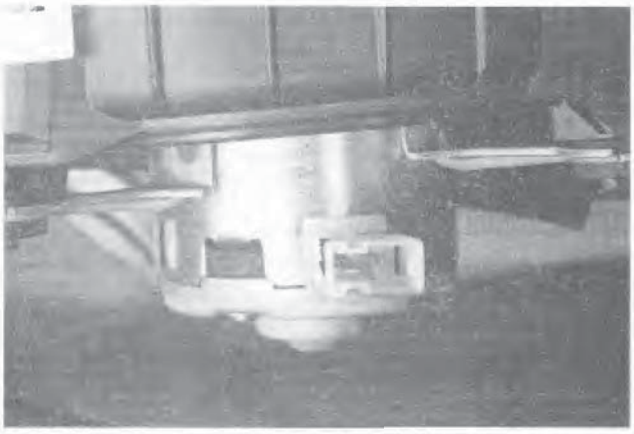
4 Backprobe the blower motor electrical connector with two small paper clips (straightened out) and connect a voltmeter to the blower motor connector and earth.

5 Move the blower switch through each of its positions and note the voltage readings. Changes in voltage indicate that the motor speeds will also vary as the switch is moved to the different positions.

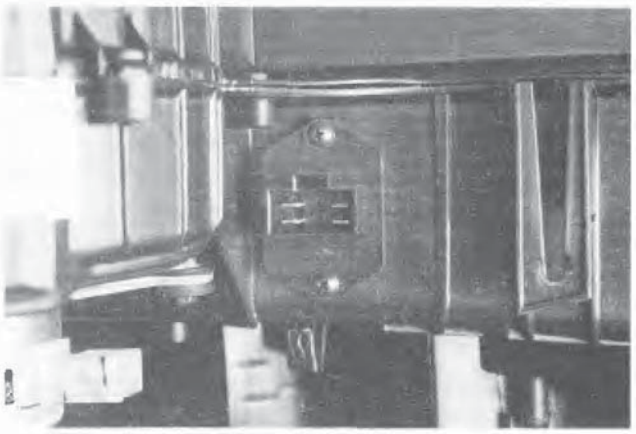
6 If there is voltage present, but the blower motor does not operate, the blower motor is probably faulty. Disconnect the blower motor connector (see illustration) and hook one side to a chassis earth and the other to a fused source of battery voltage. If the blower doesn't operate, it is faulty.

7 If there was no voltage present at the blower motor at one or more speeds, and the motor itself tested OK, check the blower motor resistor. Remove the lower storage compartment from the instrument panel, the left instrument panel end cap and the instrument storage compartment roof to access the blower resistor.

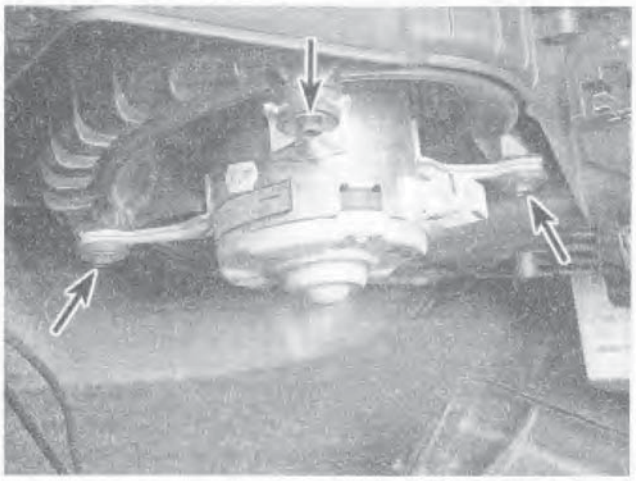
8 Backprobe the connector to the resistor while it is connected and look for varying voltages at each position (see illustration).



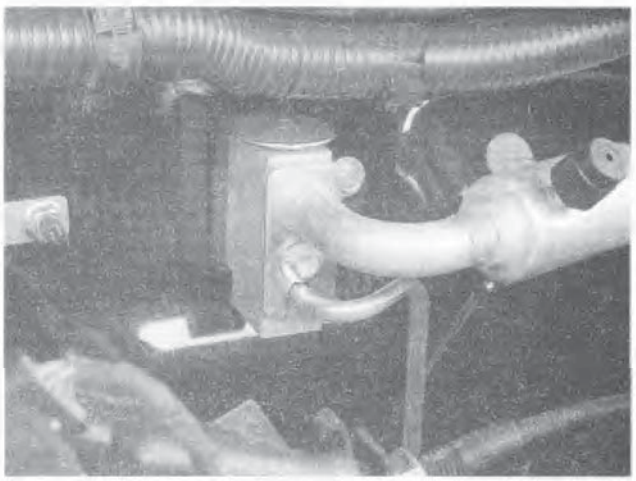
9.6 The connector at the blower motor can be used to check the motor



9.8 The blower motor resistor can be backprobed with a multimeter



10.4 The blower motor and fan are retained by three screws



11.5 The air conditioning refrigerant lines are connected to the expansion valve. Remove all these components and discard the O-rings

9 Remove the resistor mounting screw, pull down the resistor and disconnect the electrical connector from the blower motor resistor. With the ignition on, check for voltage at each of the terminals in the connector as the blower speed switch is moved to the different positions. If the voltmeter responds correctly to the switch then the resistor is probably faulty. If there is no voltage present from the switch, then the switch, control panel or related wiring is probably faulty.

10 Blower motor - removal and refitting

Refer to illustration 10.4

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

1 Unclip the left footwell upper closing panel.

2 Disconnect the electrical connector from the blower motor bottom cover.

3 Remove the three screws from the bottom cover on the blower motor. Remove the cover.

4 Remove the three screws from the blower motor (see illustration).

5 Lower the blower motor and fan out.

Note: *There are balancing clips on the fan. Do not disturb or lose them during handling.*

6 Refitting is the reverse of removal.

11 Heater assembly and heater core - removal and refitting

Warning 1: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

Warning 2: *The air conditioning system is under high pressure. DO NOT loosen any fittings or remove any components until after the system has been discharged. Air conditioning refrigerant should be properly discharged into an approved container at a dealership service department or an automotive air conditioning facility. Always wear eye protection when disconnecting air conditioning system fittings.*

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

Note: *The heater core removal procedure is extremely difficult. Attempt it only if you are certain that you have sufficient time and experience.*

HEATER ASSEMBLY

Refer to illustrations 11.5, 11.7, 11.8a and 11.8b

1 Disconnect the battery cable at the negative battery terminal.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Drain the cooling system (see Chapter 1). Have the A/C system evacuated - see **Warning 2** above. Disable the airbag system - see **Warning 1** above.

3 Remove the entire instrument panel assembly, along with all controls and related components. Remove the centre console assembly. Refer to Chapter 11 for both procedures.

4 Disconnect the heater hoses at the heater core inlet and outlet on the engine side of the firewall and plug the open fittings. If the hoses are stuck to the pipes, cut them off. Label then disconnect the vacuum hoses in the engine compartment which connect to the heater.

5 Disconnect and remove the air conditioning suction and liquid tubes from the firewall. Remove the expansion valve housing to which they attach (see illustration).

6 Disconnect the passenger airbag electrical harness. Remove the two nuts and lift off the airbag assembly.

7 Remove all three air ducts from the heater unit. Disconnect all vacuum and electrical wires at the heater box (see illustration).

8 From inside, remove the screws holding the heater case to the dash (see illustration). *From the engine compartment,* remove the retaining screws (see illustration)

9 Pull out the drain grommet fitting as you remove the heater assembly.

10 Refitting is the reverse of removal.

11 Refill the cooling system (see Chapter 1). Have the air conditioning system serviced. Enable the airbag system (refer to Chapter 12).

12 Start the engine and check for proper operation.

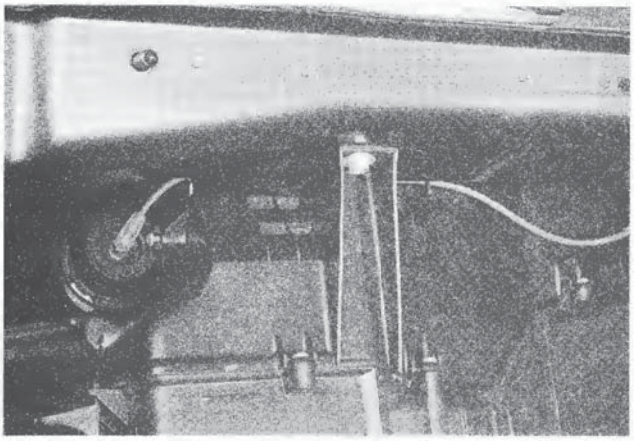
HEATER CORE

***Note:** When refitting the heater core, make sure any original insulating/sealing materials are in place around the heater core pipes and around the core.*

13 Remove the heater assembly (refer to Step 1).

14 Prise the heater tube retaining cover from the case.

15 Remove the heater core retaining strap.



11.8a The heater assembly is secured by screws along the inside of the instrument panel...

11.7 Label then disconnect all wires and vacuum hoses leading to the heater box

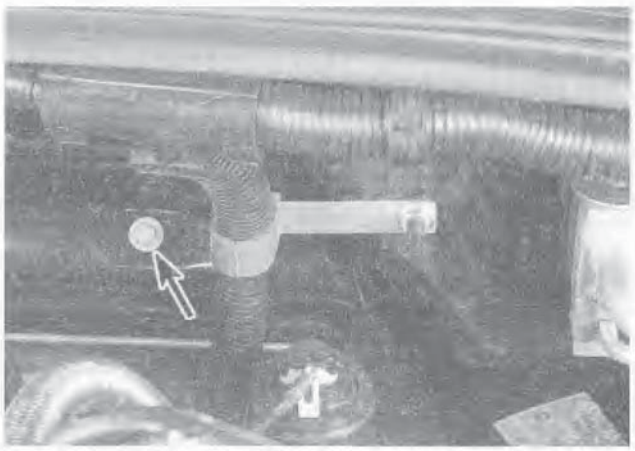
16 Carefully lift out the heater core.

17 Refitting is the reverse of removal.

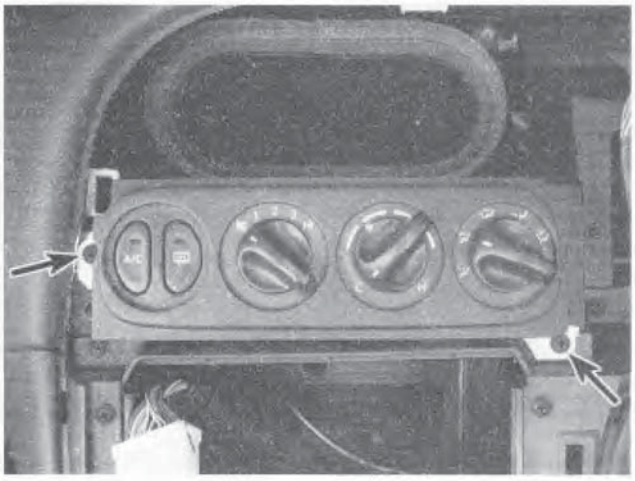
12 Heater and air conditioning control assembly - check, removal and refitting

Refer to illustrations 12.4 and 12.5

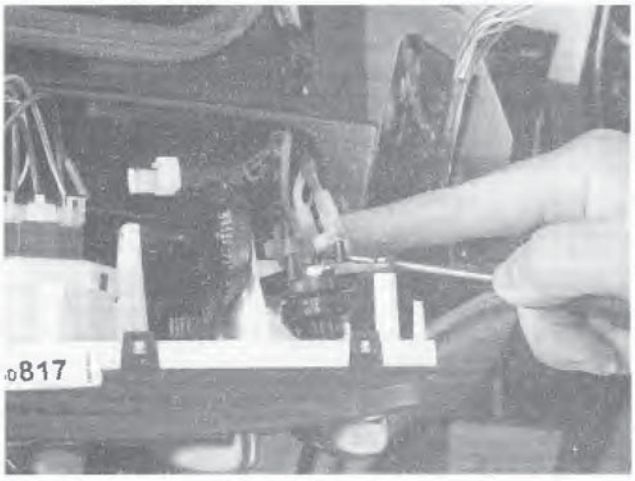
***Warning:** These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*



11.8b ... and by screws passing through the firewall from the engine side



12.4 The control assembly is secured with screws (arrows)



12.5 Pull the control unit partially out and disconnect the electrical and vacuum connectors

1 Disconnect the battery cable from the negative battery terminal.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the instrument panel front cover (refer to Chapter 11).

3 Disconnect the in-car temperature sensor from vehicles with electronic climate control.

4 Remove the screws securing the control assembly to the dash (see illustration).

5 Pull out the unit slightly and disconnect the wiring connectors and the vacuum hoses. Label all the connectors and hoses as they are removed (see illustration).

6 To refit the control assembly, reverse the removal procedure.

***Caution:** When reconnecting vacuum lines to the control assembly, do not use any lubricant to make them slip on easier, it can affect vacuum operation. If necessary, use a drop of plain water to make reconnection easier.*

13 Air conditioning and heating system - check and maintenance

***Warning:** The air conditioning system is under high pressure. DO NOT loosen any fittings or remove any components until after the system has been discharged. Air conditioning refrigerant should be properly discharged into an approved recovery container at a dealership service department or an automotive air conditioning repair facility. Always wear eye protection when disconnecting air conditioning system fittings.*

***Note:** All models use a CCTXV (cycling clutch thermostatic expansion valve) system with a receiver/dryer. It uses environment-friendly R-134a refrigerant. Do not attempt to use R-12 refrigerant in these systems.*

1 The following maintenance steps should be performed on a regular basis to ensure that the air conditioner continues to operate at peak efficiency:

a) Check the drivebelt (see Chapter 1).

b) Check the condition of the hoses. Look for cracks, hardening and deterioration. Look at potential leak areas (hoses and fittings) for signs of refrigerant oil leaking out.

***Warning:** Do not renew air conditioning hoses until the system has been discharged by a dealership or air conditioning repair facility.*

c) Check the fins of the condenser for leaves, bugs and other foreign material. A soft brush and compressed air can be used to remove them.

d) Check the wire harness for correct routing, broken wires, damaged insulation, etc. Make sure the electrical connectors are clean and tight.

e) Maintain the correct refrigerant charge.

2 The system should be run for about 10 minutes at least once a month. This is particularly important during the winter months because long-term non-use can cause hardening of the internal seals.

3 Because of the complexity of the air conditioning system and the special equipment required to effectively work on it, accurate troubleshooting of the system should be left to a certified air conditioning technician.

4 If the air conditioning system doesn't operate at all, check the fuse panel. Check the HVAC fuse and the air conditioning compressor relay.

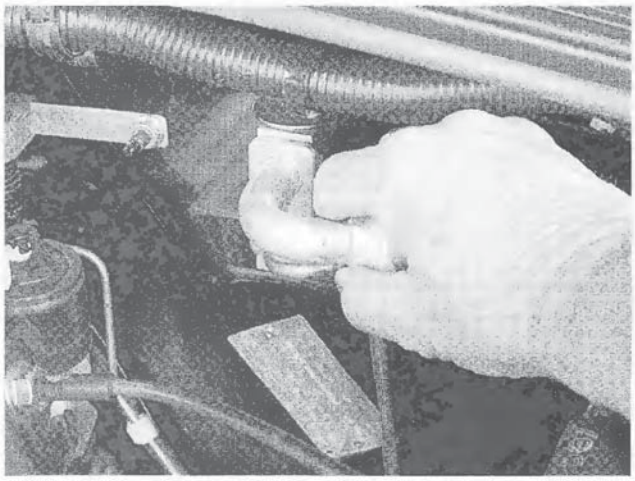
5 The most common cause of poor cooling is simply a low system refrigerant charge. If a noticeable drop in cool air output occurs, the following quick check will help you determine if the refrigerant level is low.

CHECKING THE REFRIGERANT CHARGE

Refer to illustration 13.8

6 Warm the engine up to normal operating temperature.

7 Place the air conditioning temperature selector at the coldest setting and the blower at the highest setting. Open



13.8 Feel the tubes on each side of the evaporator at this point - one should feel warm and the other cold

the doors (to make sure the air conditioning system doesn't cycle off as soon as it cools the passenger compartment).

8 With the compressor engaged - the clutch will make an audible click and the centre of the clutch will rotate - feel the surface of the receiver/dryer and the small diameter line to the evaporator. If the smaller diameter line feels warm and the receiver/dryer feels cool, the system is properly charged. Feel the pipes on each side of the expansion tube - there should be a noticeable difference in temperature (see illustration).

9 Place a thermometer in the dashboard vent nearest the evaporator and add refrigerant to the system until the indicated temperature is around 5 to 8 degrees C. If the ambient (outside) air temperature is very high, say 43 degrees C, the duct air temperature may be as high as 15 degrees C, but generally the air conditioning is 15 to 25 degrees C cooler than the ambient air.

Note: Humidity of the ambient air also affects the cooling capacity of the system. Higher ambient humidity lowers the effectiveness of the air conditioning system.

HEATING SYSTEMS

10 If the carpet under the heater core is damp, or if antifreeze vapour or steam is coming through the vents, the heater core is leaking. Remove it (see Section 11) and fit a new unit (most radiator shops will not repair a leaking heater core).

11 If the air coming out of the heater vents isn't hot, the problem could stem from any of the following causes:

a) The thermostat is stuck open, preventing the engine coolant from warming up enough to carry heat to the heater core. Renew the thermostat (see Section 3).

b) A heater hose is blocked, preventing the flow of coolant through the heater core. Feel both heater hoses at the firewall. They should be hot. If one of them is cold, there is an obstruction in one of the hoses or in the heater core, or the heater control valve is shut. Detach the hoses and back flush the heater core with a water hose. If the heater core is clear but circulation is impeded, remove the two hoses and flush them out with a water hose.

c) If flushing fails to remove the blockage from the heater core, the core must be renewed (see Section 11).

14 Air conditioning compressor - removal and refitting

REMOVAL

***Warning:** The air conditioning system is under high pressure. DO NOT loosen any fittings or remove any components until after the system has been discharged. Air conditioning refrigerant should be properly discharged into an approved container at a dealership service department or an automotive air conditioning repair facility. Always wear eye protection when disconnecting air conditioning system fittings.*

***Note:** The accumulator (see Section 16) or receiver/dryer should be renewed whenever the compressor is renewed. If you choose to not renew it, seal the ports with caps, plugs or tape immediately after disconnecting the fittings.*

1 Have the air conditioning system discharged (see **Warning** above). Disconnect the cable from the negative terminal of the battery.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Clean the compressor thoroughly around the refrigerant line fittings.

3 Remove the serpentine/drivebelt (see Chapter 1).

4 Where necessary, raise the vehicle and support it securely on jackstands. Disconnect the electrical connector from the air conditioning compressor on all models.

5 Disconnect the suction and discharge lines from the compressor. Both lines are mounted to the compressor with a plate secured by one nut. Plug the open fittings to prevent the entry of dirt and moisture, and discard the seals between the plate and compressor.

6 Remove the compressor mounting bolts and nuts and remove the compressor from the engine compartment.

REFITTING

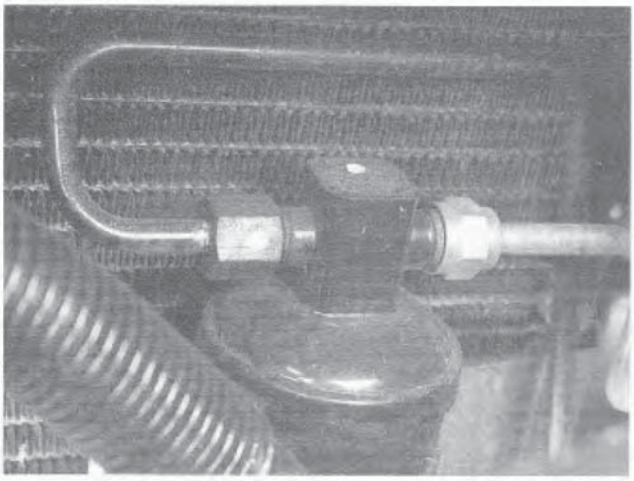
7 If a new compressor is being fit, pour the oil from the old compressor into a graduated container and add that exact amount of new refrigerant oil to the new compressor. Also follow any directions included with the new compressor.

***Note:** Some renewal compressors come with refrigerant oil in them. Follow the directions with the compressor regarding the draining of excess oil prior to refitting.*

***Caution:** The oil used must be labelled as compatible with R-134a refrigerant systems.*

8 Refitting is basically the reverse of removal. When refitting the line fitting bolt to the compressor, use new seals lubricated with clean refrigerant oil (seals and oil must be compatible with the refrigerant used), and tighten the bolt securely.

9 Reconnect the battery cable to the negative battery terminal.



15.3 Label then disconnect the refrigerant lines from the receiver/dryer

10 Have the system evacuated, recharged and leak tested by a dealership service department or an automotive air conditioning repair facility.

15 Air conditioning receiver/drier - removal and refitting

REMOVAL

Refer to illustration 15.3

Warning: *The air conditioning system is under high pressure. DO NOT loosen any fittings or remove any components until after the system has been discharged. Air conditioning refrigerant should be properly discharged into an approved container at a dealership service department or an automotive air conditioning repair facility. Always wear eye protection when disconnecting air conditioning system fittings.*

1 Have the air conditioning system discharged (see **Warning** above). Disconnect the cable from the negative terminal of the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Refer to Section 16. The condenser must be almost completely removed from the vehicle in order to access the receiver/drier.

3 Mark the IN and OUT port locations of the receiver/drier before removing it (see illustration).

REFITTING

4 If you are renewing the receiver-drier, add 28 grams of fresh refrigerant oil to the new unit (oil must be compatible with the R-134a system used).

5 Place the new receiver/drier into position in the bracket.

6 Refit the inlet and outlet lines, using clean refrigerant oil on the new O-rings.

Note: *The fitting marked IN must connect to the IN port of the receiver/drier.*

Tighten the mounting bolt securely.

7 Connect the cable to the negative terminal of the battery.

8 Have the system evacuated, recharged and leak tested by a dealership service department or an automotive air conditioning repair facility.

16 Air conditioning condenser - removal and refitting

Warning 1: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

Warning 2: *The air conditioning system is under high pressure. DO NOT loosen any fittings or remove any components until after the system has been discharged. Air conditioning refrigerant should be properly discharged into an approved container at a dealership service department or an automotive air conditioning repair facility. Always wear eye protection when disconnecting air conditioning system fittings.*

REMOVAL

Refer to illustrations 16.4 and 16.7

1 Have the air conditioning system discharged (see **Warning 2** above). Disconnect the cable from the negative terminal of the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the radiator (refer to Section 5).

3 Working through the front bumper, disconnect the tube from the passenger side of the receiver/dryer.

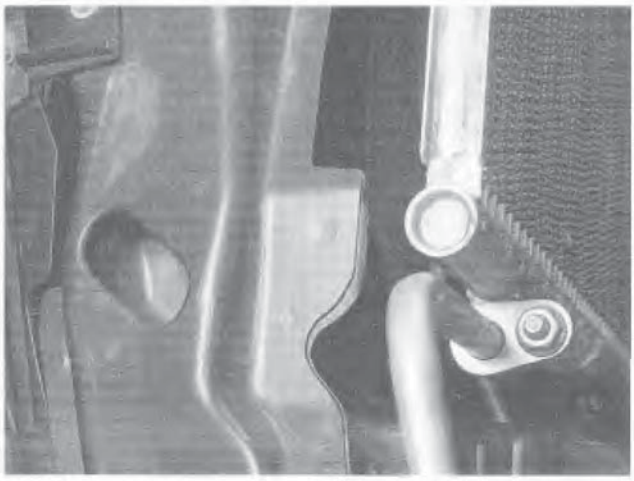
4 Disconnect the discharge refrigerant line fitting from the condenser and cap the open fittings to prevent the entry of dirt and moisture (see illustration).

5 On vehicles with electronic climate control, disconnect the temperature sensor from the right front of the condenser.

6 Tilt the condenser towards the engine. Disconnect the remaining receiver/dryer tube and remove the receiver/dryer.

7 Pull the condenser from the brackets.

Caution: *The condenser is made of aluminium - be careful not to damage it during removal. If necessary a plastic tool can be used to straighten bent fins (see illustration).*



16.4 Disconnect the discharge tube from the condenser at this point

16.7 A plastic "fin comb" can be used to straighten bent fins - the tool has a head for various fins-per-mm spacings

REFITTING

8 Refitting is the reverse of removal.

Note: Refer to Section 15 for the correct refitting procedure of the receiver/drier. Be sure to use new, compatible O-rings on the refrigerant line fittings (lubricate the O-rings with clean refrigerant oil, compatible with R-134a refrigerant). If a new condenser is fit, add 28 grams of new refrigerant oil to the system.

9 Have the system evacuated, recharged and leak tested by a dealership service department or an automotive air conditioning repair facility.

17 Air conditioning evaporator - removal and refitting

Warning 1: These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.

Warning 2: The air conditioning system is under high pressure. DO NOT loosen any fittings or remove any components until after the system has been discharged. Air conditioning refrigerant should be properly discharged into an approved container at a dealership service department or an automotive air conditioning repair facility. Always wear eye protection when disconnecting air conditioning system fittings.

Note: Refer to the illustrations for the heater core removal in Section 11. The evaporator removal requires the removal of the entire heater assembly just as in the heater core procedure.

1 Have the air conditioning system discharged (see **Warning 2** above). Disconnect the cable from the negative terminal of the battery.

Caution: On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).

2 Drain the cooling system (refer to Chapter 1).

3 Remove the entire heater assembly (refer to Section 11).

4 Disconnect the vacuum line from the actuator on the upper heater assembly housing.

5 Remove the five screws and lift off the upper housing from the heater unit.

6 Disconnect the vacuum line clips from the cover on the evaporator.

7 On manual heater models, disconnect the rod and quadrant from the evaporator cover.

8 On models with electronic climate control, disconnect the tube and the wiring connector from the evaporator cover.

9 Remove the four screws from the cover of the evaporator.

10 Very carefully remove the evaporator core.

11 Check the core over carefully for signs of leaks. The efficiency can be improved slightly if any bent fins are straightened with a "fin comb" (see illustration 16.7).

12 If a new evaporator core is to be fit, save all of the sealing gaskets from the original unit and transfer them.

13 Refitting is the reverse of the removal procedure. Be sure to re-fill the cooling system (see Chapter 1). Use new R-134a-compatible O-rings on all connections, lubricated by compatible refrigerant oil.

14 If a new evaporator has been fit, add 28 grams of refrigerant oil. Have the system evacuated, recharged and leak tested by a dealership service department or an automotive air conditioning repair facility.

Notes

Chapter 4
Fuel and exhaust systems

Contents

Specifications

Fuel pressure

5.0 litre V8 and 3.8 litre V6 non-supercharged models	270 to 350 kPa
3.6 litre V6 models	410 kPa
V6 supercharged models	290 to 410 kPa
5.7 litre Gen. III and 6.0 litre Gen. IV V8 models	410 kPa

Torque specifications

	Nm
Air plenum-to-inlet manifold bolts	
3.8 litre V6 models	15
3.6 litre V6 models	23
Engine dress cover nuts	10
Fuel tank sender unit bolts	2.0 to 3.5
Fuel rail-to-inlet manifold bolts	10
Supercharger bolts	
Step 1	10 to 18
Step 2	21 to 27
Throttle body fasteners	
3.8 litre V6 models	15 to 20
3.6 litre V6 models	8 to 12
5.0 litre V8 models	15 to 18
5.7 litre Gen. III and 6.0 litre Gen. IV V8 models	12
Throttle cable lock nuts	3 to 4
IAC valve screws	1.0 to 1.5

1 General information

The fuel system consists of a fuel tank, an electric fuel pump, a fuel pump relay, an air cleaner assembly and a fuel injection system. Supercharged V6 models are also equipped with a fuel pump control module located in the boot which commands additional fuel pressure from the fuel pump during high speed operation.

FUEL INJECTION SYSTEM

Fuel injection provides optimum mixture ratios at all stages of combustion. Combined with its immediate response characteristics, fuel injection permits the engine to run on the best possible air/fuel mixture, which greatly reduces exhaust gas emissions.

The fuel injection system is controlled directly by the vehicle's Electronic Control Module (ECM) or Powertrain Control Module (PCM), which adjusts the air/fuel mixture in accordance with engine load and performance. Because each cylinder is equipped with an injector mounted immediately adjacent to the inlet valve, much better control of the air/fuel mixture ratio is possible.

FUEL PUMP AND LINES

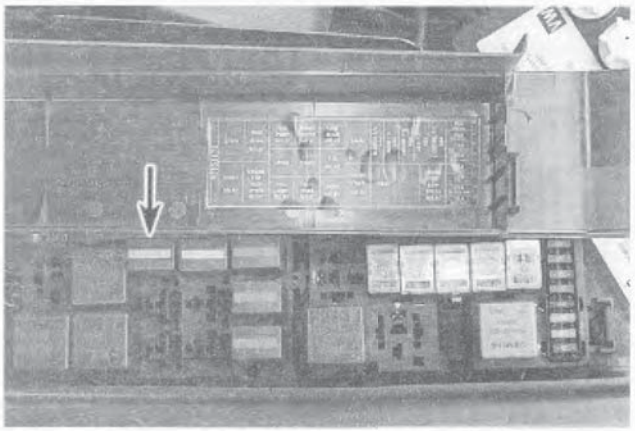
Fuel is circulated from the fuel tank to the fuel injection system, and back to the fuel tank, through a pair of lines running along the underside of the vehicle. An electric fuel pump is attached to the fuel sending unit inside the fuel tank. On some models, an additional pump is mounted under the car at the rear. A return system routes all vapours and excess fuel back to the fuel tank through separate return lines.

EXHAUST SYSTEM

The exhaust system includes an exhaust manifold fitted with, depending on the model, between one and four exhaust oxygen sensors, a catalytic converter, an exhaust pipe, and a muffler. The catalytic converter is an emission control device added to the exhaust system to reduce pollutants. A single-bed converter is used in combination with a three-way (reduction) catalyst. Refer to Chapter 6 for more information regarding the catalytic converter.

FUEL INJECTION SYSTEM

Fuel injection provides optimum mixture ratios at all stages of combustion. Combined with its immediate response characteristics, fuel injection permits the engine to run on the best possible air/fuel mixture, which greatly reduces exhaust gas emissions.



2.3 The fuel pump relay is located in the underbonnet electrical centre. It is clearly labeled

2 Fuel pressure relief procedure

Refer to illustration 2.3

Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first. When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

Note: *After the fuel pressure has been relieved, it's a good idea to lay a shop towel over any fuel connection to be disassembled, to absorb the residual fuel that may leak out when servicing the fuel system.*

1 Before servicing any fuel system component, you must relieve the fuel pressure to minimize the risk of fire or personal injury.

2 Remove the fuel filler cap - this will relieve any pressure built up in the tank.

3 Use the following method:

a) Remove the fuel pump relay from the fuse box in the engine compartment (see illustration).

b) Start the engine and allow it to idle until it dies. Crank the engine for 10 seconds more.

4 Unless this procedure is followed before servicing fuel lines or connections, fuel spray (and possible injury or fire) may occur.

3 Fuel pump/fuel system pressure - check

Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Section 2). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

Note: *The following checks assume the fuel filter is in good condition. If you doubt its condition, fit a new one (see Chapter 1).*

PRELIMINARY CHECKS

1 Check for an adequate fuel supply in the fuel tank.

2 Remove the fuel filler cap and listen for fuel pump operation (indicated by a whirring sound) at the fuel tank filler neck as an assistant turns the ignition key On.

3 If the fuel pump is operating but you suspect a fuel pump problem, proceed to the fuel pump pressure check. If no sound is heard, indicating the pump is not operating, proceed to the fuel pump electrical circuit check.

FUEL PUMP PRESSURE CHECK

Refer to illustration 3.5

***Note:** A special fuel pressure gauge (capable of reading high pressure) and the necessary adapters to connect the gauge to the fuel line quick-connect fittings or Schrader valve fitting, and a fuel line shut-off adapter will be needed to perform a fuel pressure check.*

4 Relieve the fuel system pressure (see Section 2).

5 On 3.8 litre V6 and 5.0 litre V8 models, disconnect the fuel supply line to the fuel rail (see Section 4) and connect the fuel gauge in the line. On all other models, connect the fuel gauge to the Schrader valve (see illustration) fitting on the fuel rail.

6 Refit the fuel pump relay and turn the ignition switch "ON". The fuel pump should run approximately two seconds, then shut off.

7 Read the fuel pressure on the gauge.

***Note:** Since the fuel pump shuts off after two seconds, it may be necessary to cycle the ignition key On and Off several times to obtain an accurate reading.*

8 Compare your reading to the value listed in this Chapter's Specifications. If the fuel pressure in not within specifications, check the following:

a) If the pressure is higher than specified, check for a pinched or clogged fuel return line. If the fuel return line is clear to the fuel tank, the fuel pressure regulator is probably defective.

b) If the pressure is lower than specified, inspect the fuel lines and fuel filter for leaks or restrictions. Install a fuel line shut-off adapter in the fuel return line and check the pressure again with the valve closed. If the pressure is now within or above specifications, the fuel pressure regulator is probably defective.

***Caution:** Do not attempt to restrict the fuel return line by pinching or kinking the line, as the nylon fuel line will be damaged.*

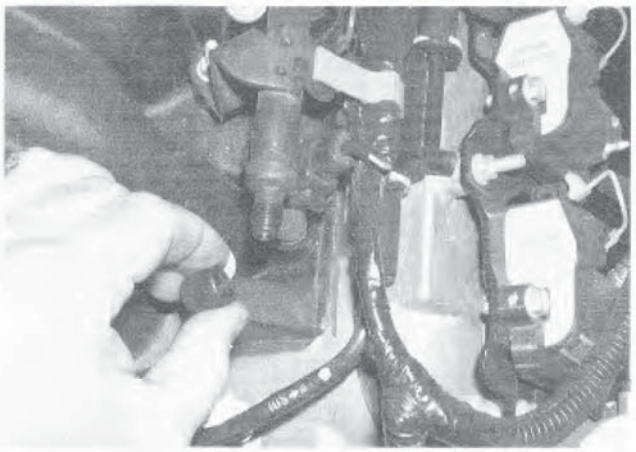
c) If the pressure is below specifications, the fuel supply line is not restricted and the fuel pressure regulator is not defective, the fuel pump is probably defective.

9 Relieve the fuel pressure (see Section 2) and remove the fuel pressure gauge.

FUEL PUMP ELECTRICAL CIRCUIT CHECK

***Note:** Refer to the wiring diagrams at the end of Chapter 12 for additional information when performing the following checks.*

10 If the fuel pump is not operating, as indicated by no sound from the fuel tank or no fuel pressure, perform the following checks to determine the problem.



3.5 Schrader valve location on the 5.7 litre Gen III V8 engine - supercharged V6 similar

11 Check the fuel pump fuse in the passenger compartment fuse box (see Chapter 12). If the fuse is defective, replace it and check for fuel pump operation. If the fuse blows again, check for a short circuit.

12 Remove the fuel pump relay (see illustration 2.3) and check for battery voltage at the terminal connected to the fuse. If battery voltage is not available and the fuse is good, check for an open in the wiring harness from the relay to the fuse box. Check for battery voltage from the Powertrain Control Module (PCM) when the ignition key is cycled On and Off. If battery voltage is not available from the PCM, check the wiring harness from the PCM to the relay, if the circuit is good, the PCM may be defective. Check for continuity to earth on the appropriate terminal.

13 Refer to Chapter 12 and check the fuel pump relay, if the relay is defective replace it and check for fuel pump operation.

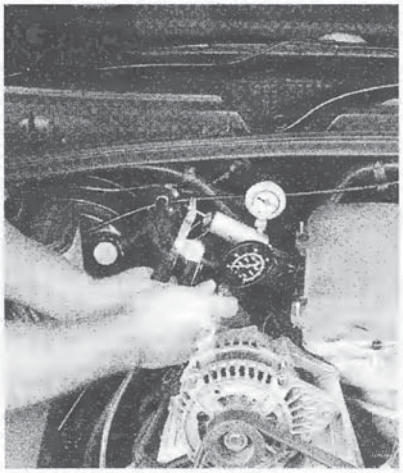
14 Raise the vehicle and support it securely on jackstands. Disconnect the fuel pump module connector at the fuel tank. Probe the connector with a test light connected to earth and check for battery power at the fuel pump power supply terminal as the ignition key is cycled On and Off. If battery power is not available and the relay and related circuits are good, check the wiring harness from the relay to the fuel pump module. Check for continuity to earth on the appropriate terminal at the fuel pump side of the connector. If power is available, the circuit to earth is good and the fuel pump fails to operate when connected, the fuel pump is probably defective. Refer to Section 7 for the renewal procedure.

15 If power is not reaching the fuel pump on supercharged V6 models, check the connections at the fuel pump control module located in the luggage compartment on top of the right rear wheel housing. The module receives a signal from the PCM to control the fuel pump at high or low speed. If the fuel pump relay and related circuits are good, the fuel pump control module may be defective.

FUEL PRESSURE REGULATOR CHECK

Refer to illustrations 3.18a and 3.18b

16 Disconnect the vacuum hose from the fuel pressure regulator. If there is any evidence of raw fuel in the vacuum hose, replace the fuel pressure regulator, the internal diaphragm is leaking.



3.18a Fit a vacuum pump to the fuel pressure regulator and check the fuel pressure without vacuum applied

3.18b Next, apply vacuum to the fuel pressure regulator and check the fuel pressure - the fuel pressure should decrease as the vacuum increases

4.8 Correct fuel hose is always clearly marked. Don't use any other type in the fuel system

17 Connect a vacuum gauge to the hose and start the engine. Manifold vacuum should be present, if it is not, check for a defective hose or plugged vacuum supply port.

18 Attach a hand-held vacuum pump to the fuel pressure regulator, start the engine and watch the fuel pressure gauge as vacuum is applied to the regulator (see illustrations). Fuel pressure should decrease slightly (approximately 40 to 60 kPa) as vacuum is applied. If the fuel pressure regulator fails to respond as described, check for a restriction in the fuel return line. If the fuel return line is clear to the fuel tank, the regulator is probably defective. Refer to Section 13 for the renewal procedure.

4 Fuel lines and fittings - repair and renewal

Refer to illustrations 4.8, 4.13a, 4.13b, 4.13c and 4.13d

Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Section 2). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

1 Always relieve the fuel pressure before servicing fuel lines or fittings on fuel-injected vehicles (see Section 2).

2 The fuel feed, return and vapour lines extend from the fuel tank to the engine compartment. The lines are secured to the underbody with clip and screw assemblies. These lines must be occasionally inspected for leaks, kinks and dents.

3 If evidence of dirt is found in the system or fuel filter during disassembly, the line should be disconnected and blown out. Check the fuel strainer on the fuel gauge sending unit (see Section 8) for damage and deterioration.

STEEL AND NYLON TUBING

4 Because fuel lines used on fuel-injected vehicles are under high pressure, they require special consideration.

5 If renewal of a metal fuel line or emission line is called for, use welded steel tubing meeting the Holden specification or its equivalent. Don't use copper or aluminium tubing to renew steel tubing. These materials cannot withstand normal vehicle vibration.

6 If is becomes necessary to renew a section of nylon fuel line, renew it only with the correct part number - don't use any substitutes.

7 Most fuel lines have threaded fittings with O-rings. Any time the fittings are loosened to service or renew components:

a) Use a backup spanner while loosening and tightening the fittings.

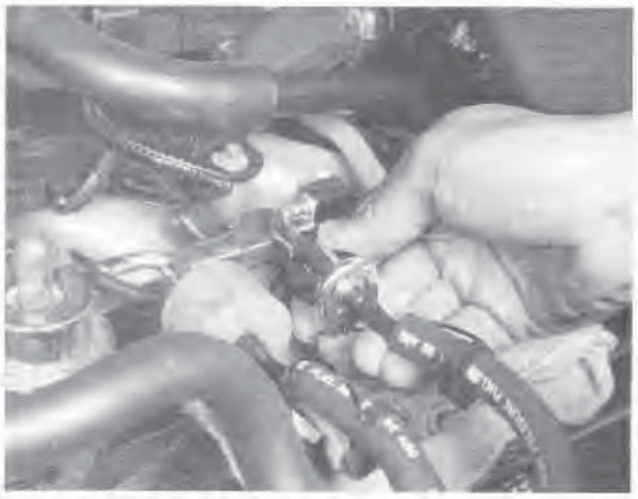
b) Check all O-rings for cuts, cracks and deterioration. Renew any that appear worn or damaged.

c) If the lines are renewed, always use original equipment parts, or parts that meet the Holden standards specified in this Section.

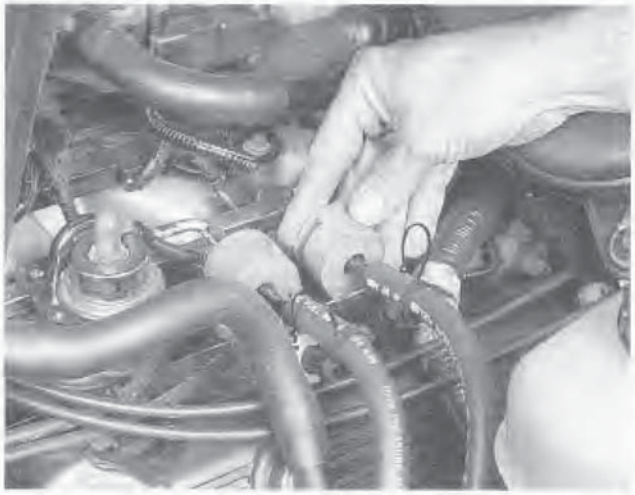
RUBBER HOSE

Warning: *These models are equipped with electronic fuel injection, use only original equipment renewal hoses or their equivalent. Others may fail from the high pressures of this system.*

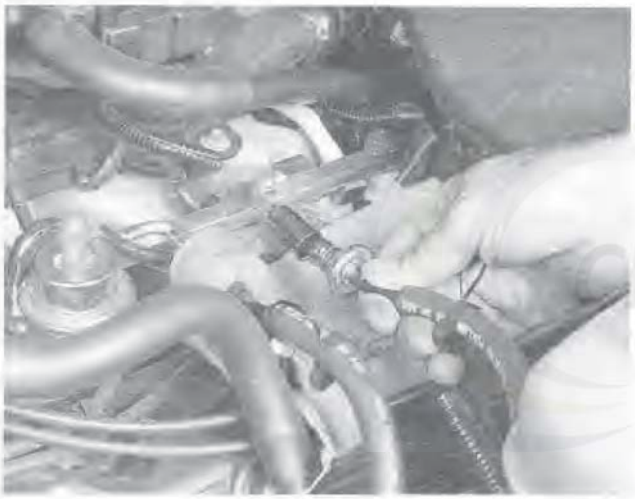
8 When rubber hose is used to renew a metal line, use reinforced, fuel-resistant hose. Hose(s) not clearly marked as fuel hoses could fail prematurely and could fail to meet emission standards (see illustration). Hose inside diameter must match line outside diameter.



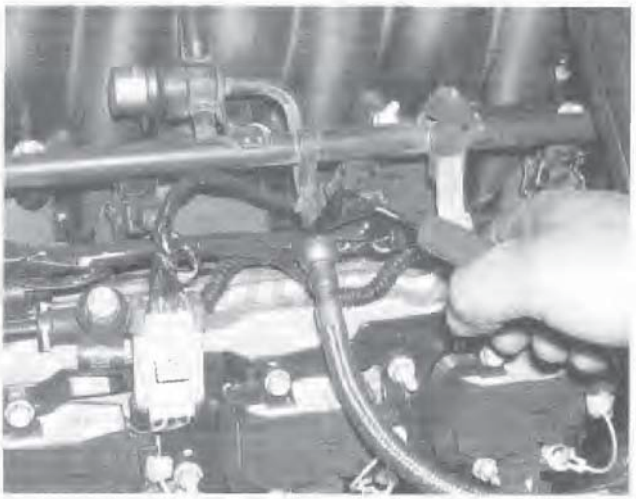
4.13a Press down to release the safety clamp refitted on the fuel line connectors



4.13b Insert the correct diameter coupling tool and slide it to release the internal lock



4.13c Insert the fuel line disconnect tool into the line and release the line - 5.7 litre Generation III V8 engine shown



4.13d Detach the fuel lines

9 Don't use rubber hose within 100 mm of any part of the exhaust system or within 250 mm of the catalytic converter. Metal lines and rubber hoses must never be allowed to chafe against the frame. A minimum of 6 mm clearance must be maintained around a line or hose to prevent contact with the frame.

REMOVAL AND REFITTING

Note: *The following procedure and accompanying illustrations are typical for vehicles covered by this manual. On quick-disconnect (non-threaded) fittings, clean off the fittings before disconnection to prevent dirt from getting in the fittings. After disconnection, clean the fittings with compressed air and apply a few drops of oil.*

10 Relieve the fuel pressure (see Section 2) and disconnect the fuel feed, return or vapour line at the fuel tank.

Note: *Some fuel line connections may be threaded. Be sure to use a back-up spanner when separating the connections.*

11 Remove all fasteners attaching the lines to the vehicle body.

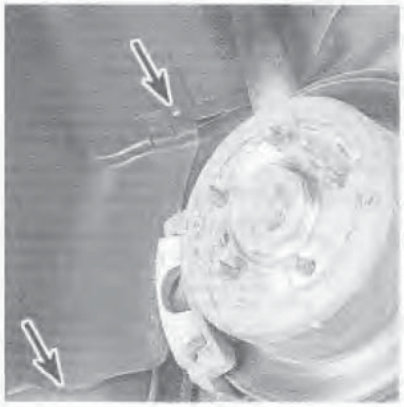
12 Detach the fitting(s) that attach the fuel hoses to the engine compartment metal lines. Twisting them back and forth will allow them to separate more easily.

13 Later model fuel lines have quick disconnect fittings. To service them:

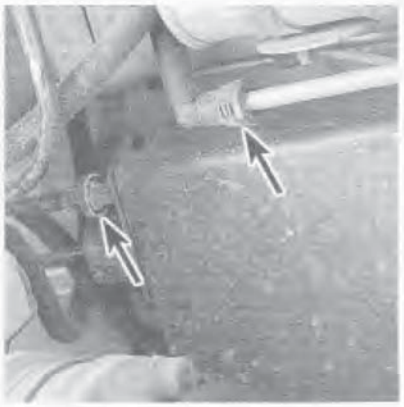
a) Open factory tool 7370 or its equivalent (available at auto parts stores). Fit it over the fuel line fitting (see illustrations).

b) Close the tool and pull it into the fitting. Pull back on the quick connect fitting.

14 Refitting is the reverse of removal. Be sure to use new O-rings at the threaded fittings, if equipped.



5.5 Remove screws and detach the shield from the right rear wheel housing



5.8 The fuel feed, return and vapour lines can be disconnected by pushing the fittings together, pressing in on the tangs and then pulling the fittings apart

5.10 Remove the fuel tank strap nuts/ bolts (arrows) from the tank

5 Fuel tank - removal and refitting

Refer to illustrations 5.5, 5.8 and 5.10

Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Section 2). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

Note: *Don't begin this procedure until the fuel gauge indicates the tank is empty or nearly empty. If the tank must be removed when it's full (for example, if the fuel pump malfunctions), siphon any remaining fuel from the tank prior to removal. Use a pump or a safety siphon device. Do not siphon by mouth.*

1 Unless the vehicle has been driven far enough to completely empty the tank, it's a good idea to siphon the residual fuel out before removing the tank from the vehicle.

Warning: *DO NOT start the siphoning action by mouth! Use a siphoning kit, available at most auto parts stores.*

2 Relieve the fuel system pressure (see Section 2).

3 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

ALL MODELS EXCEPT UTILITY

4 Raise the vehicle and support it securely on jackstands placed underneath the jacking points.

5 Remove the filler guard in the right rear wheel well (see illustration).

6 Remove the vent hoses from the filler neck.

7 Locate the electrical connector for the electric fuel pump and fuel gauge sending unit and unplug it.

8 Disconnect the fuel feed and return lines and the vapour return line. This can be done by pushing the fittings together, pressing in the tangs then pulling the fittings apart (see illustration). Remove the fuel filter if it interferes. Disconnect the earth wire from the fuel tank.

9 Support the fuel tank with a floor jack. Place a flat block of wood on top of the jack.

10 Disconnect both fuel tank retaining straps (see illustration).

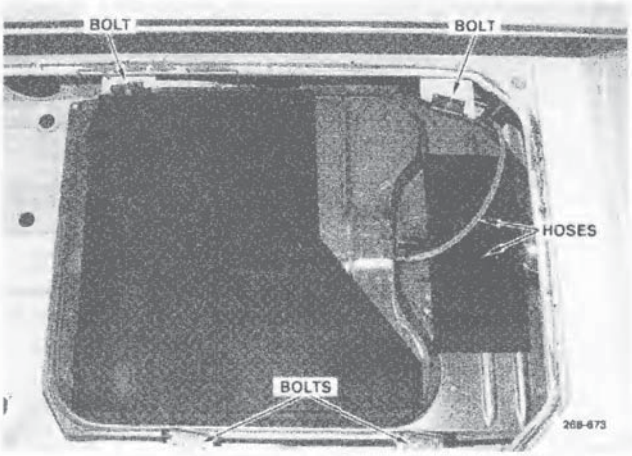
11 Remove the tank from the vehicle.

12 Refitting is the reverse of removal.

UTILITY MODELS

Refer to illustration 5.16

13 Drain the fuel from the tank using a hand pump or siphon. Do not siphon fuel using the mouth.



5.16 Location of the fuel tank with the floor panel removed - utility model

14 Remove the retaining screws and remove the front floor panel from the load compartment.
15 Remove the retaining screws and remove the side cover panel from the front right hand side of the load compartment
16 Mark and disconnect the vent hoses from the top of the fuel tank (see illustration).
17 Loosen the clamp and disconnect the hose from the filler neck.
18 Loosen the second clamp, separate the vapour separator from the filler hose and disconnect the hose from the filler neck.
19 Remove the fuel tank retaining bolts and partially withdraw the fuel tank from the vehicle.
20 Disconnect the wiring from the front of the fuel tank.
21 Mark and disconnect the fuel supply and return hoses from the fuel tank.
22 Remove the fuel tank from the vehicle.
23 Apply petroleum jelly to the filler hose to aid in installation.
24 Refitting is the reverse of removal.

6 Fuel tank cleaning and repair - general information

1 All repairs to the fuel tank or filler neck should be carried out by a professional who has experience in this critical and potentially dangerous work. Even after cleaning and flushing of the fuel system, explosive fumes can remain and ignite during repair of the tank.
2 If the fuel tank is removed from the vehicle, it should not be placed in an area where sparks or open flames could ignite the fumes coming out of the tank. Be especially careful inside garages where a gas-type appliance is located.

7 Fuel pump - removal and refitting

Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Section 2). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

Note: *On supercharged V6 models, the fuel pump cannot be renewed separately. The entire sender/pump assembly must be renewed with a new modular fuel pump/sender unit.*

REMOVAL

Refer to illustrations 7.4, 7.6, 7.7a, 7.7b, 7.8a, 7.8b and 7.10

1 Relieve the fuel system pressure (see Section 2).
2 Disconnect the earth (-) lead from the battery.

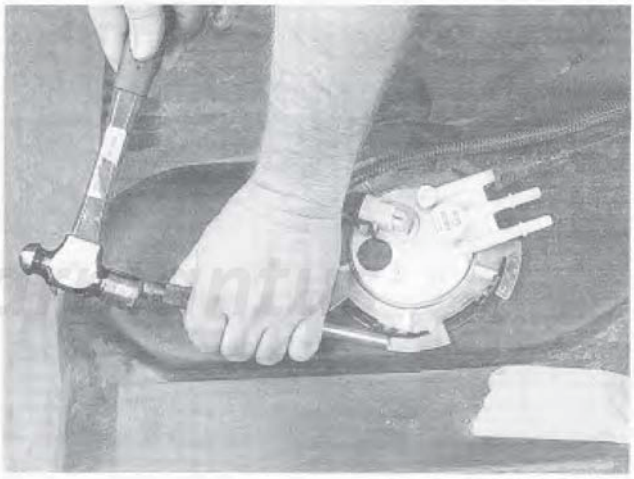
Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

3 Remove the fuel tank (see Section 5).
4 Remove the fuel level sending unit/fuel pump assembly by turning the lock-ring (see illustration). Refer to Section 8.

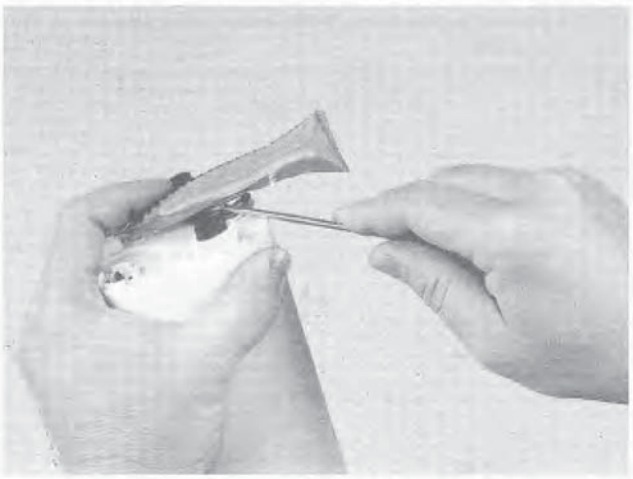
Caution: *The fuel level float and sending unit are delicate. Do not bump them against the tank during removal or the accuracy of the sending unit may be affected.*

Note: *The assembly will pop upwards when the lock-ring is loosened.*

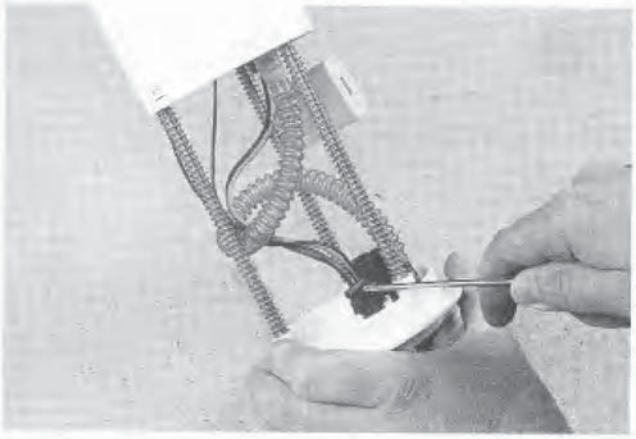
5 Inspect the condition of the gasket around the opening of the tank. If it is dried, cracked or deteriorated, renew it.
6 Carefully pull the strainer and the O-ring from the inlet fitting (see illustration). Be very careful to avoid damage to the pump end cover and the strainer.



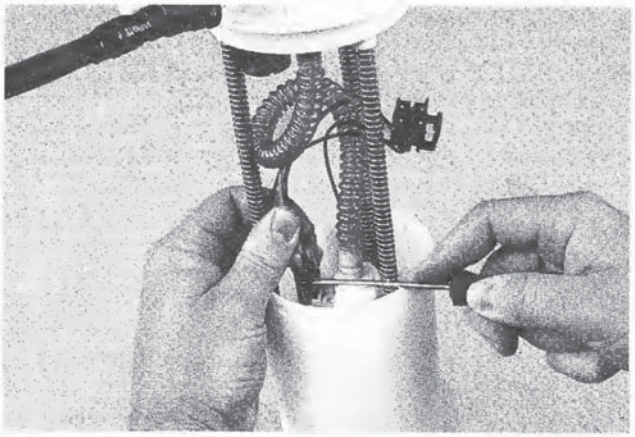
7.4 Remove the lock-ring from the fuel tank by turning it anti-clockwise



7.6 The strainer and its O-ring can be carefully pulled from the module



7.7a Disconnect the fuel pump wiring with a small screwdriver



7.7b Detach the locking tabs and unplug the wiring harness from the pump

7 Disconnect the wiring from the fuel pump (see illustrations).
8 Carefully release the retaining tabs on the cover one at a time, turning the cover clockwise as you do so (see illustration). Remove the cover and disconnect the wiring connector (see illustration).
9 Remove the snap-ring from the pump outlet fitting.
10 Remove the baffle and pump assembly by turning it anti-clockwise and pulling it from its retainer (see illustration).

REFITTING

11 Renew the seal/damper.
12 Place the snap-ring of the fuel pump onto the retainer. Position the opening in the snap-ring facing the electrical connector.
13 Push the assembly onto the retainer while turning it clockwise until it seats.
14 Place the outlet tube over the retainer, aligning the opening of the snap-ring with the electrical wiring connector. Press it into place. Make certain that the snap-ring engages fully.
15 Place the upper assembly partially into the reservoir, aligning the three tabs.
16 Connect the wiring harnesses.
17 Refit the strainer.
18 The remainder of refitting is the reverse of removal.

8 Fuel level sending unit - check and renewal

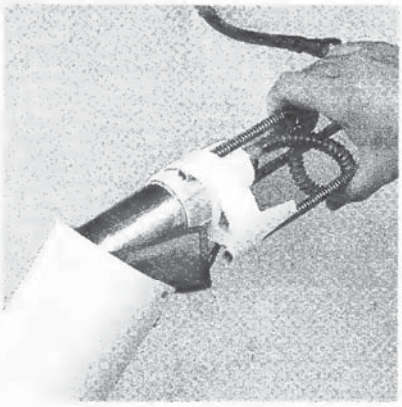
Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags when- they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Section 2). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

CHECK

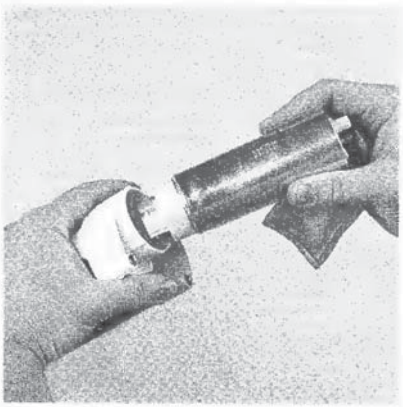
Refer to illustrations 8.5a and 8.5b

1 Raise the vehicle and secure it on jackstands.
2 Position the probes of an ohmmeter onto the fuel level sending unit electrical connector terminals and check for resistance.

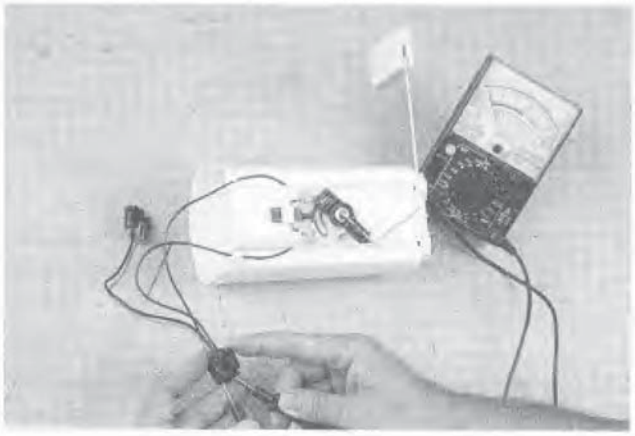
7.8a Use a small screwdriver to push in on the two tangs to release the outer reservoir



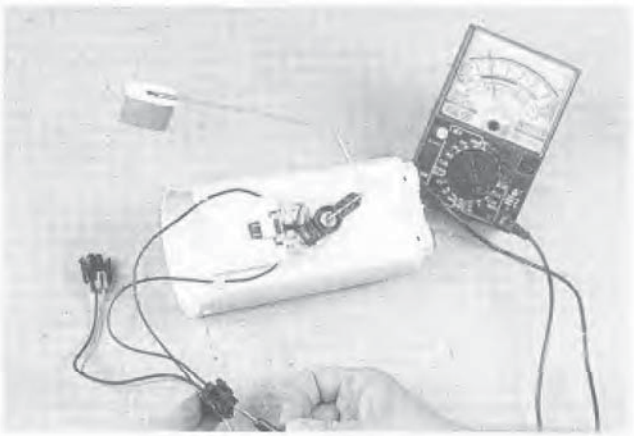
7.8b Remove the outer reservoir



7.10 Twist the fuel pump to remove it from the housing



8.5a Check the resistance of the fuel level sender unit from one extreme position...



8.5b ...to the other

3 First, check the resistance of the sending unit with the fuel tank completely full.
4 Wait until the tank is nearly empty and check the resistance of the unit again.
5 If there is very little change in resistance as the float travels from full to empty, renew the fuel level sending unit assembly.

> ***Note:*** *The fuel level sending unit can be better checked by removing the fuel pump/sender unit from the tank (see Section 7) and checking the resistance while moving the float from full (arm at highest point of travel) to empty (arm at lowest point of travel (see illustrations).*

RENEWAL

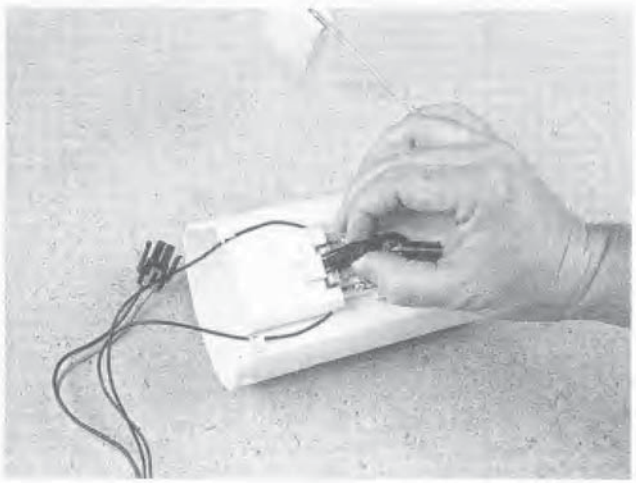
Refer to illustrations 8.9 and 8.10

6 Remove the fuel tank (refer to Section 5).
7 Remove the combination fuel pump/sender assembly from the fuel tank (refer to Section 7).
8 Pull the strainer from the bottom of the assembly (note its position before you do so).
9 Unplug the sender electrical connectors (see illustration).
10 Use needle nose pliers to squeeze the locking tabs together and detach the sender from the modular pump/sender housing (see illustration).
11 Refitting is the reverse of removal.
12 Before refitting the pump, stand the assembly up and measure the distance from a level surface to the base of the sender float. If the measurement is not approximately 10 mm, adjust the float position by bending the float arm as necessary.

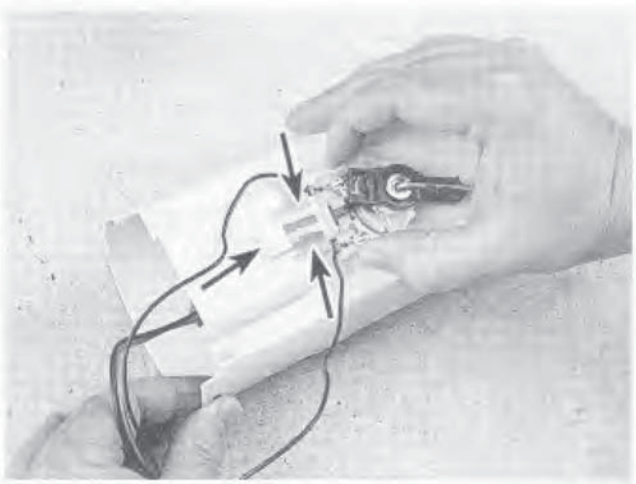
9 Air cleaner housing - removal and refitting

Refer to illustration 9.4

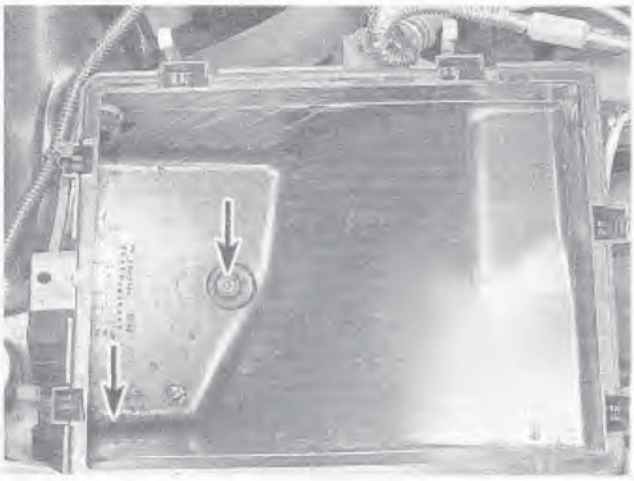
1 Disconnect the air inlet duct from the filter housing.
2 Disconnect the wiring to the IAT sensor on the filter housing.
3 Release the clips holding the upper lid in place. Remove the upper lid and the filter element.



8.9 Unplug the sending unit electrical connector



8.10 Squeeze the retaining tangs with needle nose pliers and slide the sender unit out (arrows)



9.4 Remove the three studs (arrows) in the bottom of the air filter housing that secure it to the inner fender

4 Remove the three studs holding the lower air filter housing (see illustration). Remove the lower housing, releasing it from the air inlet duct as you do so.

5 Refitting is the reverse of removal. Make sure to align the notches in the housing, the inlet duct and the clamp to achieve an airtight seal.

10 Accelerator cable - renewal and adjustment

V6 AND 5.0 LITRE V8 ENGINES

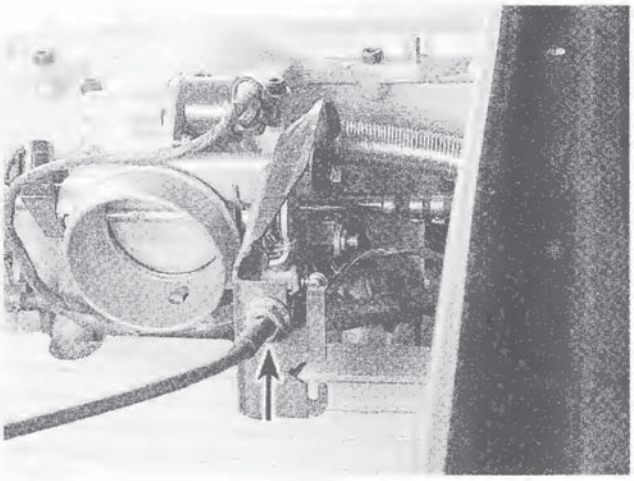
Renewal

Refer to illustration 10.3

1 Remove the engine dress cover which interferes.

2 Loosen the outer cable lock nuts at the mounting bracket.

3 Disconnect the outer cable from the bracket (see illustration).



10.3 The accelerator cable (arrow) can be disconnected from the bracket at this point. On models so equipped, the cruise control cable fits into the slot next to the accelerator cable

4 Disconnect the inner cable from the throttle body.

5 Remove the lower right trim panel from beneath the steering column. Refer to Chapter 11.

6 Disconnect the inner cable plastic spacer from the pedal assembly.

7 Pull the cable from the engine compartment.

8 Refitting is the reverse of removal.

> ***Note:*** *To prevent possible interference, flexible components (hoses, wires, etc.) must not be routed within 5 centimetres of moving parts, unless routing is controlled with straps, etc. Do not refit the trim panel until the adjustment is done.*

9 Operate the accelerator pedal and check for any binding condition by completely opening and closing the throttle.

10 At the engine compartment side of the firewall, apply sealant around the accelerator cable.

Adjustment

11 Check that the pedal stops at the proper position. It must rest against the pedal stop.

12 Adjust the outer cable lock nuts so that there is deflection or sag of 10 to 15 mm of the inner cable when it is pressed with a finger before the throttle lever begins to move. Tighten the nuts to the torque listed in this Chapter's Specifications.

13 Check for full throttle operation and free movement.

14 Refit the lower trim panel.

5.7 LITRE GENERATION III V8 ENGINES

Renewal

Refer to illustration 10.17

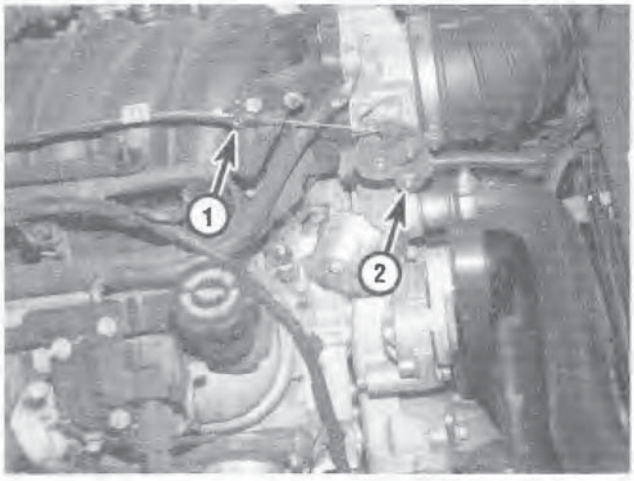
15 Remove the engine dress cover.

16 Unclip the cable(s) from the mounting bracket.

17 Disconnect the inner cable from the throttle body (see illustration).

18 Remove the lower right trim panel from beneath the steering column. Refer to Chapter 11.

19 Disconnect the inner cable plastic spacer from the pedal assembly.



10.17 Unclip the cable from the mounting bracket (1), then remove the cable from the throttle cam (2)

20 Pull the cable from the engine compartment.

21 Refitting is the reverse of removal.

> ***Note:*** *To prevent possible interference, flexible components (hoses, wires, etc.) must not be routed within 5 centimetres of moving parts, unless routing is controlled with straps, etc. Do not refit the engine dress cover until the adjustment is done.*

22 Operate the accelerator pedal and check for any binding condition by completely opening and closing the throttle.

23 At the engine compartment side of the firewall, apply sealant around the accelerator cable.

Adjustment

Refer to illustration 10.25

24 Check to see that the pedal stops at the proper position. It must rest against the pedal stop.

25 Release the outer cable housing adjustment lock (see illustration) and pull the cable lightly away from the throttle body, until the throttle cam begins to move.

26 Release the tension from the cable and allow the throttle cam to rest on the stop. Compress the cable lock on the outer cable (see illustration 10.25) about 1 mm to lock the cable.

> ***Note:*** *On models fitted with cruise control, make sure there is no slack in the cable before locking the cable adjustment lock.*

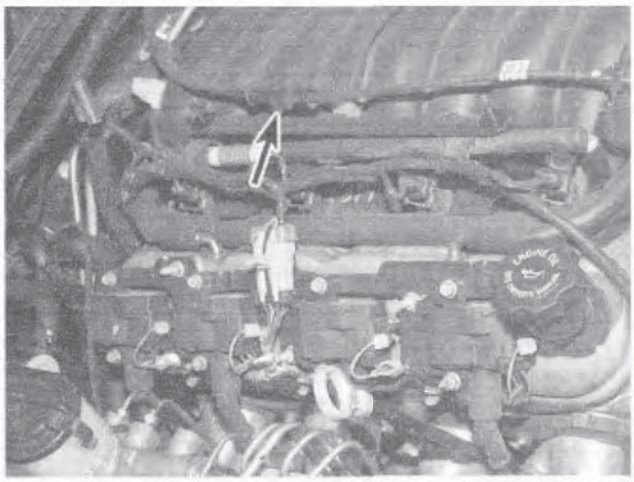
27 Check for full throttle operation and free cable movement.

28 Refit the engine dress cover.

11 Fuel injection system - general information

These models are equipped with multi-port fuel injection systems. Fuel injection provides optimum mixture ratios at all stages of combustion. Combined with its immediate response characteristics, fuel injection permits the engine to run on the best possible air/fuel mixture, which greatly reduces exhaust gas emissions.

All vehicles have a sequential fuel injection system which injects fuel directly into the inlet port of each cylinder according to its firing order. This system relies on a camshaft position sensor as well as a crankshaft position sensor to inform the PCM of engine position at all times.



10.25 Throttle cable adjustment and lock location (arrow)

The fuel injection system is controlled directly by the vehicle's Powertrain Control Module (PCM), which automatically adjusts the air/fuel mixture in accordance with engine load and performance.

The injection system consists of an air inlet manifold, the throttle body, the injectors, the fuel rail assembly, an electric fuel pump and associated plumbing.

Air is drawn through the air cleaner and throttle body. A Mass Air Flow (MAF) sensor compensates for temperature and pressure variations.

While the engine is running, the fuel constantly circulates through the fuel rail, which removes vapours and keeps the fuel cool while maintaining sufficient pressure to the injectors under all running conditions.

The fuel injection system is controlled by the PCM so that it works in conjunction with the rest of the vehicle functions to provide optimum driveability and emissions control.

Because the system meters fuel and air precisely, it is important to the proper operation of the vehicle that the fuel and air filters be changed at the specified intervals.

The PCM has a learning capability for certain performance conditions. If the battery is disconnected, part of the PCM memory is erased, which makes it necessary to "re-learn" the computer. This is done by thoroughly warming up the engine and operating the vehicle at part throttle, stop and go and idle conditions.

A fuel pump relay is used to control the electric fuel pump operation. When the ignition is turned on, the fuel pump relay immediately supplies current to the fuel pump to pressurize the fuel system. If the engine doesn't start after two seconds, the fuel pump will automatically shut off.

The throttle stop screw, used to regulate the minimum idle speed, is adjusted at the factory and sealed with a plug to discourage attempts at adjustment.

12 Fuel injection system - check

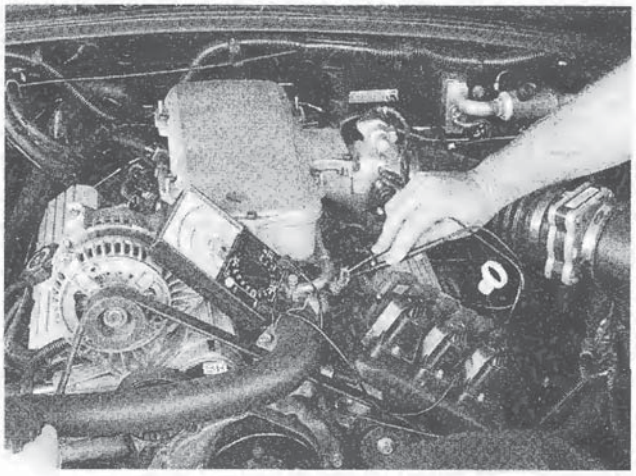
> ***Warning:*** *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water. Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Section 2). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

> ***Note:*** *The following procedure is based on the assumption that the fuel pump is working and the fuel pressure is adequate (see Section 3).*

PRELIMINARY CHECKS

1 Check all electrical connectors that are related to the system. Loose electrical connectors and poor grounds can cause many problems that resemble more serious malfunctions.

12.8 Use a stethoscope or screwdriver to determine if the injectors are working properly - they should make a steady clicking sound that rises and falls with engine speed changes



12.9 Measure the resistance of each injector - if any are open or shorted they must be renewed. The resistances should not vary more than a few ohms from one to the next

2 Check to see that the battery is fully charged, as the control unit and sensors depend on an accurate supply of voltage in order to properly meter the fuel.

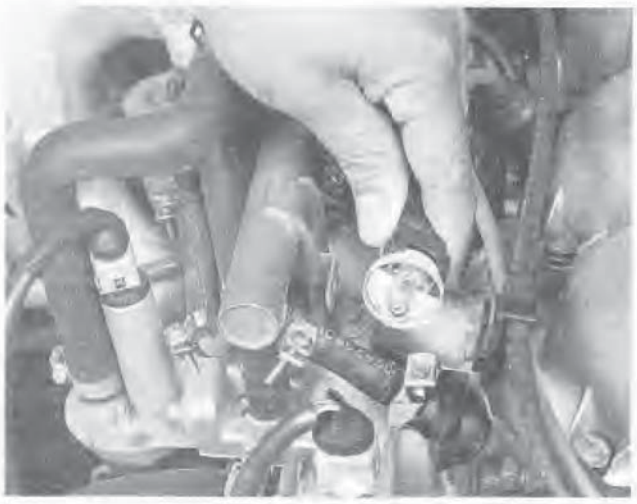
3 Check the air filter element - a dirty or partially blocked filter will severely impede performance and economy (see Chapter 1).

4 Check the earth wire connections on the inlet manifold for tightness. Check all electrical connectors that are related to the system. Loose connectors and poor grounds can cause many problems that resemble more serious malfunctions.

5 Check the air inlet duct to the inlet manifold for leaks, which will result in an excessively lean mixture. Also check the condition of all vacuum hoses connected to the inlet manifold.

6 Remove the air inlet duct from the throttle body and check for dirt, carbon or other residue build-up inside the throttle body. If it's dirty, clean it with carburettor cleaner and a toothbrush or rag.

7 Check the fuel system pressure (see Section 3).



12.10 Refit the "noide" light into each injector electrical connector and confirm that it blinks when the engine is cranking or running

SYSTEM CHECKS

Refer to illustrations 12.8, 12.9 and 12.10

8 With the engine running, place an automotive stethoscope against each injector, one at a time, and listen for a clicking sound, indicating operation (see illustration). If you don't have a stethoscope, place the tip of a screwdriver against the injector and listen through the handle.

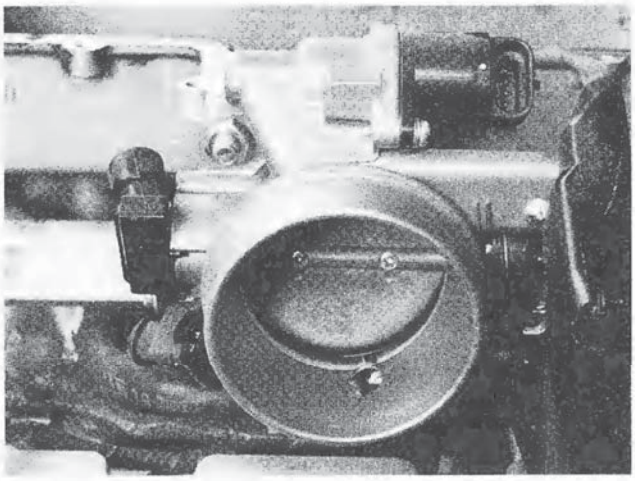
9 Unplug the injector electrical connectors and test the resistance of each injector (see illustration). Compare the values to each other. They should all be very close (within a few ohms). If any injector is shorted, open or has a resistance which is different than the others by more than about 5 ohms, renew it.

10 Fit an injector test light ("Noide" light) into each injector electrical connector, one at a time (see illustration). Crank the engine over. Confirm that the light flashes evenly on each connector. This will test for voltage to the injectors.

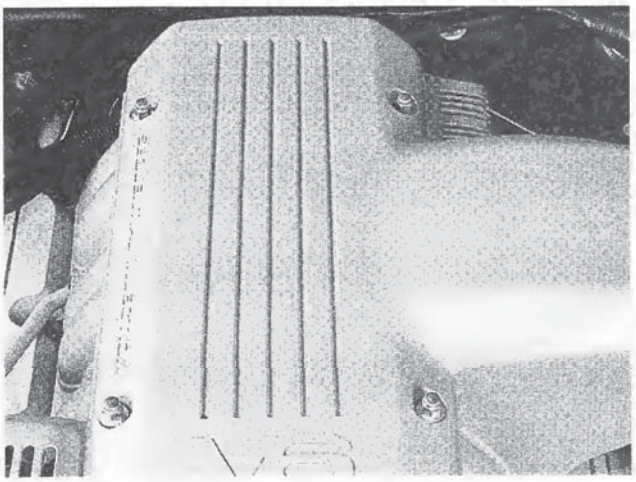
11 The remainder of the system checks can be found in the following Sections.

13 Fuel injection system - component check and renewal

Warning: *Petrol is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a gas-type appliance (such as a water heater or a clothes dryer) is present. Since petrol is carcinogenic, wear latex gloves when there's a possibility of being exposed to fuel, and, if you spill any fuel on your skin, rinse it off immediately with soap and water Mop up any spills immediately and do not store fuel-soaked rags where they could ignite. The fuel system is under constant pressure, so, if any fuel lines are to be disconnected, the fuel pressure in the system must be relieved first (see Section 2). When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*



13.2 Clean the inside of the throttle body with carburettor cleaner to remove sludge deposits. This should be done periodically to improve driveability



13.4 Remove the engine cover - V6 model shown

THROTTLE BODY

Check

Refer to illustration 13.2

1 Detach the air inlet duct from the throttle body and move the duct out of the way.

2 On models with a throttle cable, have an assistant depress the throttle pedal while you watch the throttle valve. Check that the throttle valve moves smoothly when the throttle is moved from closed (idle position) to fully open (wide open throttle).

Note: *Spray carburettor cleaner into the throttle body, especially around the shaft area to free-up any binding caused by the accumulation of carbon deposits or sludge buildup (see illustration).*

3 Wiggle the throttle lever while watching the throttle shaft inside the bore. If it appears worn (loose), renew the throttle body unit.

Removal

Refer to illustrations 13.4 and 13.10

Warning: *Wait until the engine is completely cool before beginning this procedure.*

4 Remove the engine dress cover(s) (see illustration).

5 Disconnect the earth (-) lead from the battery, then raise the vehicle and support it securely on jackstands.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

6 Detach the air inlet duct and set it aside.

7 On early models, unplug the Idle Air Control (IAC) valve and the Throttle Position Sensor (TPS) electrical connectors (see Chapter 6). On late models, disconnect the wiring from the throttle control valve.

8 Mark and disconnect all the vacuum hoses connected to the throttle body. Also detach the breather hose, if equipped.

9 Disconnect the accelerator cable and cruise control cable from the throttle lever (see illustration 10.3), then detach any interfering brackets and the cable housing from its bracket (see Section 10).

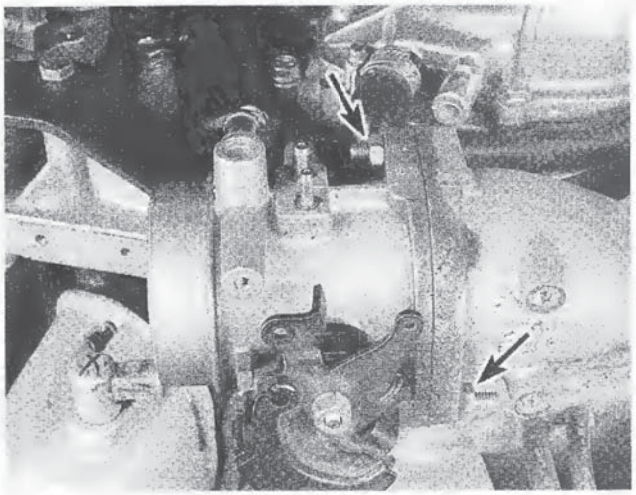
10 Remove the throttle body nuts and detach the throttle body (see illustration).

Refitting

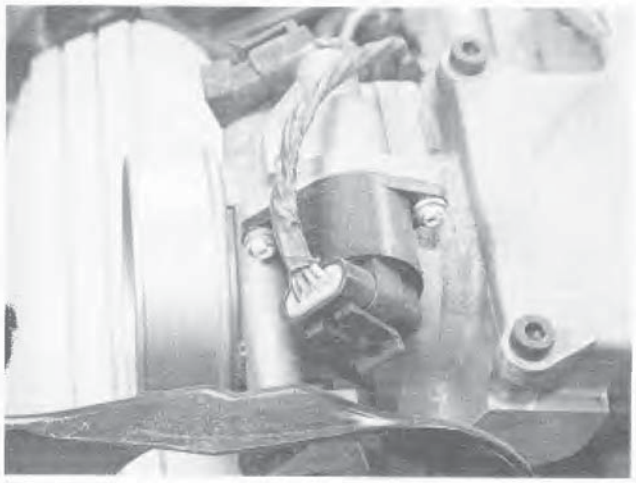
11 Clean off all traces of old gasket material from the throttle body and the plenum.

12 Fit the throttle body and a new gasket and tighten the nuts to the torque listed in this Chapter's Specifications. Use no sealer on the gasket.

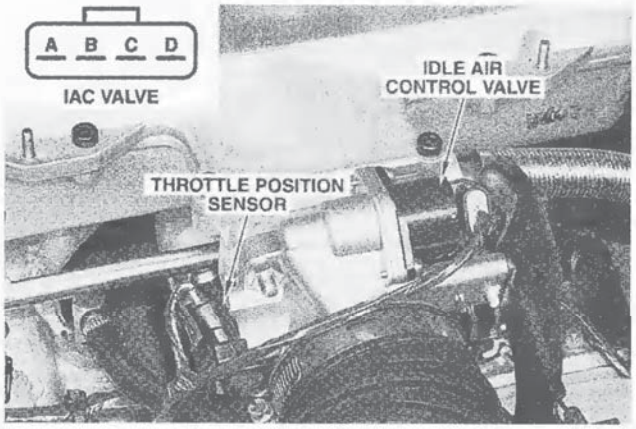
13 The rest of the procedure is the reverse of removal.



13.10 Remove the throttle body nuts (arrows) - V6 model shown, V8 similiar



13.14 The IAC motor on the non-supercharged V6 engine. It is readily accessible from above



13.15 First measure the resistance across terminals D and C, then across terminals A and B

IDLE AIR CONTROL (IAC) VALVE

Check

Refer to illustrations 13.14 and 13.15

14 The idle air control valve (IAC) controls the engine idle speed (see illustration). This output actuator is mounted on the throttle body and is controlled by voltage pulses sent from the PCM (computer). The IAC valve pintle moves in or out allowing more or less inlet air into the system according to the engine conditions. To increase idle speed, the PCM retracts the IAC valve pintle away from the seat and allows more air to bypass the throttle bore. To decrease idle speed, the PCM extends the IAC valve pintle towards the seat, reducing the air flow.

15 To check the IAC valve, unplug the electrical connector and, using an ohmmeter, measure the resistance across terminals A and B, then terminals C and D. Each resistance check should indicate 40 to 80 ohms (see illustration). If not, renew the IAC valve. There also must not be any continuity between the two pairs of terminals.

16 There is an alternate method for testing the IAC valve. Various SCAN tools are available from auto parts stores and specialty tool companies that can be plugged into the DLC (diagnostic link connector) for the purpose of monitoring the sensors. Connect the SCAN tool and switch to the Idle Air Motor Position mode and monitor the steps (motor winding position). The SCAN tool should indicate between 10 to 200 steps depending upon the rpm range. Allow the engine to idle for several minutes and while observing the count reading, snap the throttle to achieve high rpm (under 3,500). Repeat the procedure several times and observe the SCAN tool steps (counts) when the engine goes back to idle. The readings should be within 5 to 10 steps each time. If the readings fluctuate greatly, renew the IAC valve.

> ***Note:*** *When the IAC valve electrical connector is disconnected for testing, the PCM will have to "relearn" its idle mode. In other words, it will take a certain amount of time before the idle motor resets for the correct idle speed. Make sure the idle is smooth and not misfiring before plugging in the SCAN tool.*

17 Next, remove the valve (see Step 18) and inspect it:

a) Check the pintle for excessive carbon deposits. If necessary, clean it with carburettor cleaner spray. Also clean the IAC valve housing to remove any deposits.
b) Check the IAC valve electrical connections. Make sure the pins are not bent and make good contact with the connector terminals.

Removal

V6 models

18 Disconnect the negative battery cable.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

19 Remove the engine dress cover and disconnect the wiring harness from the valve.

20 Remove the mounting screws and remove the IAC valve.

V8 models

21 Remove the throttle body (refer to Step 1). Remove the attaching screws and lift off the IAC valve.

All models

22 Check the condition of the rubber O-ring, If it's hardened or deteriorated, renew it. On models equipped with a gasket, remove the gasket.

23 Clean the sealing surface and the bore of the idle air/vacuum signal housing assembly to ensure a good seal.

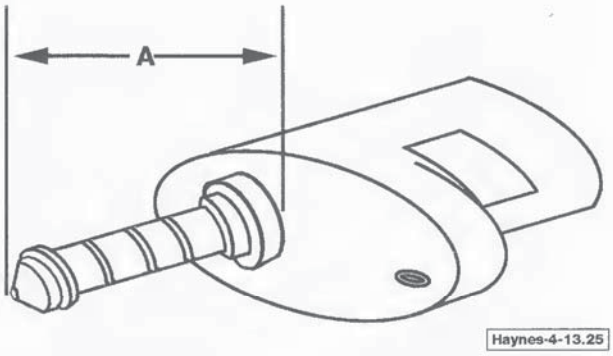
> ***Caution:*** *The IAC valve itself is an electrical component and must not be soaked in any liquid cleaner, as damage may result.*

24 Before fitting the IAC valve, the position of the pintle must be checked. If the pintle is extended too far, damage to the assembly may occur.

Refitting

Refer to illustration 13.25

25 Measure the distance from the flange or gasket mounting surface of the IAC valve to the tip of the pintle. If the distance is greater than 28 mm, reduce the distance by applying firm



13.25 The amount that the pintle protrudes from the housing (A) must not be more than 28 mm. To retract it, simply use your hand to firmly push it back in

force onto the pintle to retract it (see illustration). Try to move the pintle side-to-side if it binds.

26 Position the new O-ring or gasket on the IAC valve. Lubricate the O-ring with a light film of engine oil. Fit the IAC valve and tighten the valve or the mounting screws securely.

27 Plug in the electrical connector at the IAC valve assembly.

> ***Note:*** *No adjustment is made to the IAC assembly after refitted. The IAC resetting is controlled by the PCM when the engine is started. The engine must be held at about 2500 rpm for twenty seconds to reset.*

28 The remainder of refitting is the reverse of removal.

THROTTLE POSITION SENSOR (TPS)

Check

29 Check for stored trouble codes in the PCM using the On Board Diagnosis system (see Chapter 6).

30 To check the operation, and for renewal of the TPS, refer to the Information Sensors in Chapter 6.

AIR INLET PLENUM (V6 NON-SUPERCHARGED ENGINE)

Refer to illustrations 13.44a, 13.44b and 13.45

31 Relieve the fuel system pressure (see Section 2).

32 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

33 Remove the engine dress cover.

34 Disconnect the wiring that connects to the mass airflow sensor. Disconnect the air inlet duct and carefully set it aside (see Section 9).

35 Disconnect the fuel supply and return lines at the quick-connect fittings (refer to Section 4).

> ***Note:*** *Don't try to disconnect the lines from the fuel rail or the fuel pressure regulator. They are permanently connected to these components.*

36 Disconnect the emission control canister lines from the throttle body.

37 Label then disconnect all the vacuum hoses from the plenum and throttle body.

38 Label then disconnect all wiring harnesses and connectors from the plenum and throttle body.

39 Remove the alternator (see Chapter 5).

40 Disconnect the throttle and cruise control cables.

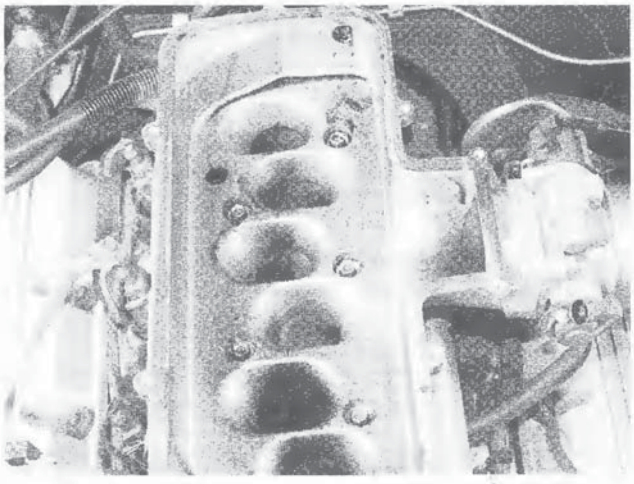
41 Label and then disconnect the wiring harnesses and connectors from the fuel injectors.

42 Remove the eight bolts holding the cover on the plenum.

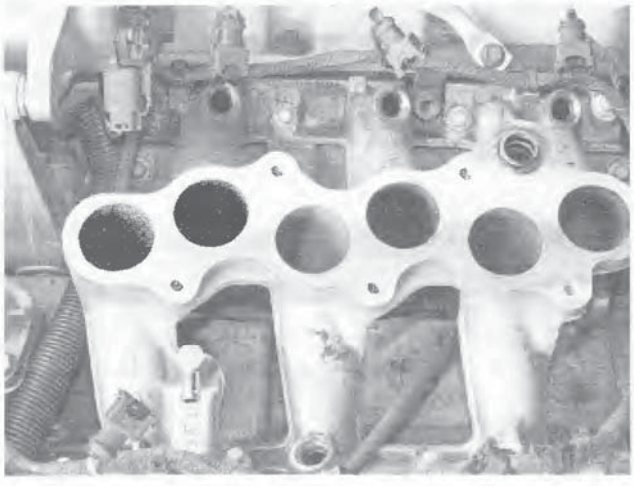
43 Remove the cover. Lay a clean rag over the open ports.

44 Remove the five bolts holding the plenum to the lower inlet manifold (see illustration).

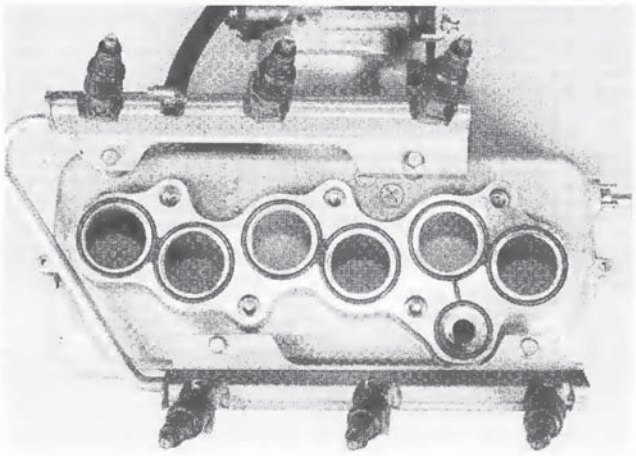
> ***Note:*** *The bolts are captive; they are held into the plenum bolt holes. Do not unscrew them more than is necessary. Carefully manipulate the plenum from the inlet manifold. The fuel rail and injectors will come with it. Cover the ports with a rag (see illustration).*



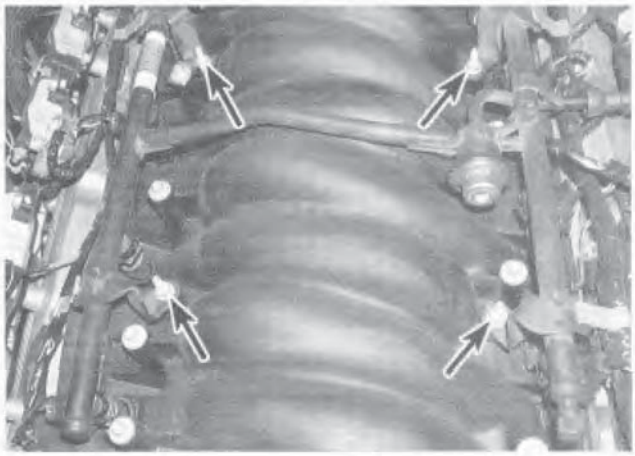
13.44a These inner bolts secure the two V6 plenum halves together



13.44b Cover this assembly with clean rags to avoid a possible disaster



13.45 The under side of the plenum does not need to have its seals renewed (or removed) unless they become damaged



13.75 Remove the fuel rail mounting stud-bolts and remove the rail - 5.7 litre Generation III V8 engine shown

45 Refitting is the reverse of removal. It is not necessary to remove or renew the rubber seals unless they have been damaged (see illustration). If they are removed from the groove in the cover they must be renewed, as they will swell in length.

***Caution:** Do not forget to remove the rags from the inlet manifold ports.*

FUEL RAIL AND INJECTORS

***Warning:** Before any work is performed on the fuel lines, fuel rail or injectors, the fuel system pressure must be relieved (see Section 2).*

***Note:** Refer to Section 12 for the injector checking procedure.*

3.8 litre V6 non-supercharged models

46 Relieve the fuel system pressure (see Section 2).

47 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

48 Clean debris and dirt from around the fuel injectors and the ports. Remove the engine trim cover.

49 Remove the inlet air duct from the throttle body.

50 Remove all hoses from the throttle body. Label then disconnect all hoses from the inlet plenum. Label then disconnect the wiring from the fuel injectors, the throttle position sensor and the idle air control valve.

51 Remove the eight bolts and the cover from the inlet manifold plenum.

52 Detach the vacuum line at the fuel pressure regulator.

53 Disconnect the supply and return fuel lines from the quick-connect fittings.

***Note:** Don't try to disconnect the lines from the fuel rail or the fuel pressure regulator. They are permanently connected to these components. Use a special fuel line tool to depress the seal inside the fuel line coupler and detach the fuel lines (refer to Section 4).*

54 Loosen the bolts that hold the inlet plenum to the manifold. Don't attempt to completely remove the bolts.

55 Carefully manipulate the plenum from the inlet manifold. The fuel rail and injectors will come with it (see illustration 13.45). Tilt the assembly and set it on top of the engine facing forward and upward.

***Caution:** Cover all open engine ports with rags or cardboard. Use care when handling the fuel rail assembly to avoid damaging the injectors.*

***Note:** An identification number is stamped on the side of the fuel rail assembly. Refer to this number if servicing or parts renewal is required.*

Supercharged V6 models

56 Relieve the fuel system pressure. Refer to Section 2.

57 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

58 Clean debris and dirt from around the fuel injectors and the ports. Remove the engine trim cover.

59 Remove the alternator support.

60 Remove the fuel pressure regulator from the fuel rail.

61 Disconnect the fuel inlet hose from the firewall (refer to Section 4)

***Note:** Don't try to disconnect the lines from the fuel rail or the fuel pressure regulator. They are permanently connected to these components.*

62 Disconnect the wiring from all of the fuel injectors.

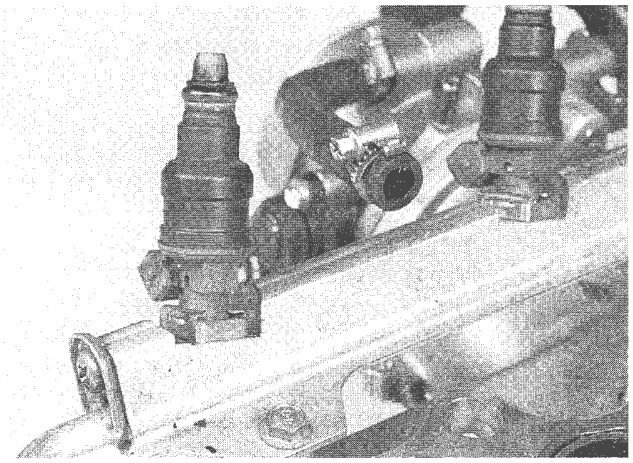
63 Unbolt and remove the fuel rail and injectors from the engine.

3.6 litre V6 models

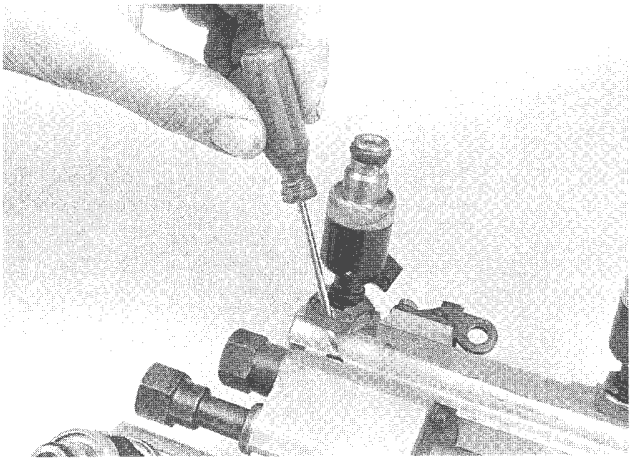
64 Relieve the fuel system pressure. Refer to Section 2.

65 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*



13.76a The individual injectors are retained by clips



13.76b To remove an injector that is retained by a spring clip, simply prise off the clip with a small screwdriver, then pull the injector from the fuel rail

66 Remove the plenum from the inlet manifold (see Chapter 2B, Section 7).

67 Using a special tool, disconnect the fuel supply line at the rear of the fuel rail and also disconnect the injector block connector adjacent to the fuel supply line.

68 Remove the retaining bolts and lift the fuel rail and injectors as an assembly from the inlet manifold.

V8 models

Refer to illustration 13.75

69 Relieve the fuel system pressure. Refer to Section 2.

70 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

71 Clean debris and dirt from around the fuel injectors and the ports. Remove the engine trim covers.

72 Disconnect both fuel hoses from the firewall on 5.0 litre models and, using a special tool, disconnect the fuel lines at the fuel on 5.7 litre Gen. III models (refer to Section 4).

73 Disconnect the wiring from all of the fuel injectors.

74 Disconnect the vacuum hose from the fuel pressure regulator.

75 Remove the plastic caps from the heads of the bolts which secure the fuel rail to the manifold. Remove the bolts and the fuel rail with the fuel injectors (see illustration).

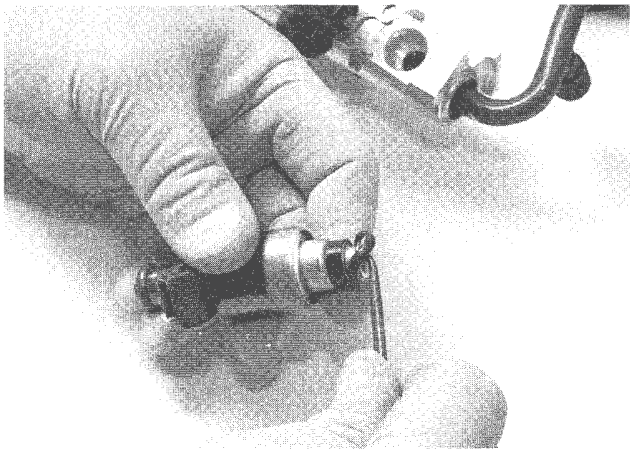
All models

Refer to illustrations 13.76a, 13.76b, 13.77a and 13.77b

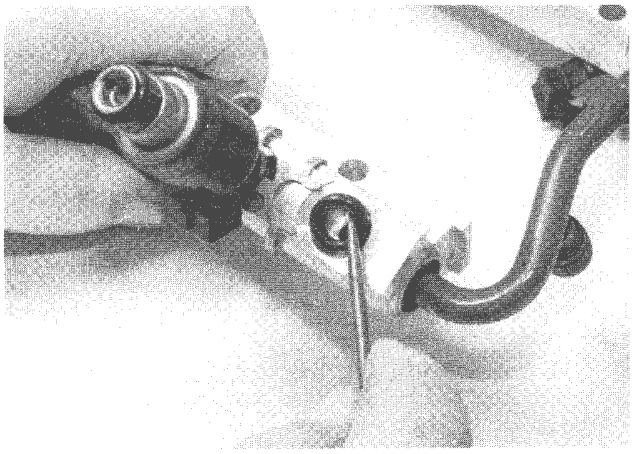
76 To remove the fuel injectors, slide the injector retaining clip and pull the injector from the fuel rail (see illustrations). Spread open the end of the injector clip slightly and remove it from the fuel rail, then extract the injector.

77 Remove the injector O-ring seals (see illustrations).

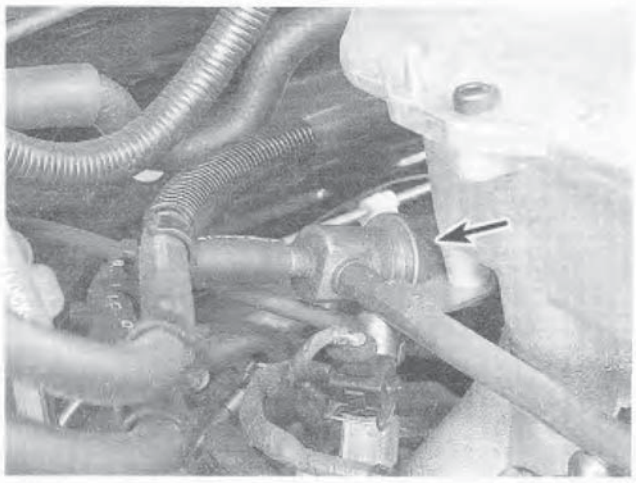
78 Fit the new O-ring seal(s), as required, on the injector(s) and lubricate them with a light film of engine oil.



13.77a Carefully prise the seals off the injectors



13.77b Remove the injector seal from the fuel rail. The injector seals that are positioned in the fuel rail are black, while the seals that go into the engine block are brown



13.85 Pull the vacuum hose off the fuel pressure regulator (arrow)

79 Fit the injectors on the fuel rail.
80 Secure the injectors with the retainer clips.
81 Refitting is the reverse of the removal procedure.

FUEL PRESSURE REGULATOR

Check

82 Refer to Section 3 for the fuel pressure checking procedure.

Renewal

V6 models

Refer to illustration 13.85

> ***Note:*** *On 3.8 litre models, the fuel pressure regulator is located on the fuel rail and is controlled by engine vacuum. On 3.6 litre engines, the fuel pressure regulator is contained within the fuel pump/sender unit assembly and the fuel supply line is maintained at a constant fuel pressure, regardless of engine speed or load.*

83 Relieve the fuel system pressure (see Section 2).
84 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

85 On 3.8L models, disconnect the vacuum hose from the regulator (see illustration). On non-supercharged engines, remove the complete fuel rail assembly (refer to Step 46).
86 On 3.6L models, remove the fuel tank/sender unit assembly (see Section 7). Separate the reservoir from the fuel pump/sender unit assembly, then remove the holder containing the fuel pressure regulator.
87 Remove the snap-ring from the regulator and pull it out.
88 On 3.8L models, disconnect the fuel return hose from the firewall using the required special tool (refer to Section 4).

> ***Note:*** *The fuel return hose is not removable from the regulator housing. If either component is damaged, the assembly must be renewed as a unit.*

V8 models

89 Relieve the fuel system pressure (see Section 2).
90 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

91 Remove the right engine trim cover.
92 Disconnect both hoses from the regulator.
93 Unbolt and remove the fuel pressure regulator.

All models

94 Reassembly is the reverse of disassembly. Be sure to renew all gaskets and seals, otherwise a dangerous fuel leak may develop. When fitting the seals, lubricate them with a light film of engine oil.
95 Start the engine and check for fuel leaks.

14 Supercharger - general information

The supercharger is not a bolt-on option. It is part of an integrated V6 engine system. The supercharger is a blow through type system with the standard port fuel injection. The supercharger is belt driven off the crankshaft and, if damaged, is renewed as a unit (it is not serviceable). The throttle body controls the amount of inlet air to the supercharger through the inlet plenum.

A bypass valve is refitted at the supercharger outlet. This valve is controlled by engine vacuum and commands from the PCM. The bypass valve controls the amount of pressurized air back into the supercharger. At low throttle, deceleration or reverse gear operation the engine runs under normal engine vacuum (some air is bypassed). At other times the bypass valve actuator closes the bypass valve, which directs all the air from the supercharger to the inlet manifold.

15 Supercharger - diagnosis

Due to the need for special tools and expertise, diagnosis of the supercharger is beyond the scope of the home mechanic and should be left to a dealer service department or other qualified repair shop.

However, other systems which affect the operation of the supercharger can be inspected, which may help to isolate the problem. Check the following:

a) All air inlet ducts - check for leaks.
b) Check the supercharger drivebelt - make sure the supercharger turns and the belt doesn't slip.
c) Tap on the air bypass actuator - if it's sticky, it may resume functioning normally when tapped.
d) Check the exhaust system for an obstruction.
e) Check all vacuum hoses for leaks.
f) Check the fuel pressure.
g) Check for leaky seals, which will be characterized by a film of oil around the front of the supercharger, and may also be accompanied by noise.

> ***Note:*** *A light film of oil is normal at the front seal area. Unless oil is literally dripping or puddling, it is not a cause for concern.*

16 Supercharger and related components - removal and refitting

SUPERCHARGER

Note: The supercharger cannot be rebuilt or overhauled. If the supercharger malfunctions, it will be necessary to renew the supercharger as a unit.

Removal

1 Disconnect the earth (-) lead from the battery.

Caution: On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).

2 Relieve the fuel system pressure (refer to Section 2).
3 Remove the dress cover from the top of the engine.
4 Label then disconnect all of the wiring connectors from the interfering engine sensors. Secure the harnesses out of the way.
5 Remove the inlet air duct along with the throttle body. Place the unit where it will not be damaged or dropped.
6 Label then disconnect all of the vacuum hoses from the interfering components.
7 Remove the screws from the boost solenoid harness and the rear engine cover.
8 Remove the bypass valve actuator harness.
9 Disconnect the wiring connectors from all six fuel injectors.
10 Remove the bracket from the alternator.
11 Remove the fuel rail and injectors (refer to Section 13).
12 Disconnect the throttle and cruise control cables.
13 Remove the throttle body (refer to Section 13).
14 Remove the supercharger drivebelt (refer to Chapter 1).
15 Unbolt and remove the supercharger.

Note: To prevent entry of foreign material, all engine openings should be covered with clean rags after the unit is removed.

Refitting

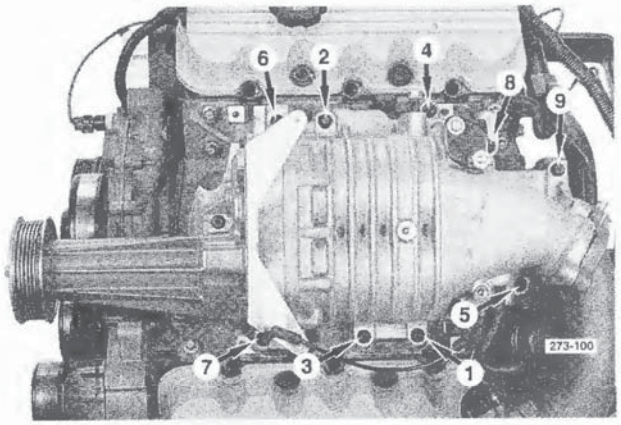
Refer to illustration 16.17

16 Clean and inspect the gasket and O-ring surfaces. Renew the supercharger gasket and the O-rings.
17 Refitting is the reverse of the removal procedure. Tighten the bolts to the torque listed in this Chapter's Specifications. Follow the correct fastener tightening sequence (see illustration).

BYPASS VALVE ACTUATOR

Removal

18 Remove the engine upper cover.
19 Disconnect the vacuum hose from the bypass valve actuator.
20 If you will be refitting the same actuator, use a scribe or paint around the heads of the two mounting bolts on the actuator bracket to note their exact positions. Remove the bolts.
21 If you will be renewing the actuator with a new part, use a small scale to accurately measure the length that the actuator rod protrudes. Measure from the mounting bracket surface to the swaged section on its shaft. Record this measurement. Remove the bolts.
22 Rotate and twist the actuator as you remove it in order to disengage the end of its rod from the lever.



16.17 Supercharger bolt tightening sequence. Make certain to tighten the fasteners in two steps to the torque listed in this Chapter's Specifications

Refitting

23 Refitting is the reverse of removal.
24 If you are refitting the original actuator, align the marks around the bolts which you made during removal.
25 If you are fitting a new actuator, refer to your notes and adjust its position to provide the same rod protrusion that existed previously.

BOOST CONTROL SOLENOID

26 Remove the engine upper cover.
27 Label then disconnect both vacuum hoses from the solenoid.
28 Disconnect the wiring harness.
29 Unbolt the solenoid from the cylinder head and remove it.
30 Refitting is the reverse of removal.

17 Exhaust system servicing - general information

Warning: The vehicle's exhaust system generates very high temperatures and must be allowed to cool down completely before any of the components are touched. Be especially careful around the catalytic converter, where the highest temperatures are generated.

Renewal of exhaust system components is basically a matter of removing the heat shields, disconnecting the component and fitting a new one. The heat shields and exhaust system hangers must be refitted in the original locations or damage could result. Due to the high temperatures and exposed locations of the exhaust system components, rust and corrosion can seize parts together. Penetrating oils are available to help loosen seized fasteners. However, in some cases it may be necessary to cut the pieces apart with a hacksaw or cuffing torch. The latter method should be employed only by persons experienced in this work.

Notes

Chapter 5
Engine electrical systems

Contents

Specifications

Ignition coil resistance (at 20 to 30 degrees C)

Primary	
3.8 litre V6 models	0.3 to 1.5 ohms
5.0 litre V8 models	0.42 to 0.47 ohms
Secondary	
3.8 litre V6 models	5,000 to 7,000 ohms
5.0 litre V8 models	5,940 to 7,260 ohms

Spark plug wire maximum resistance

3.6 litre V6 model	Not applicable
3.8 litre V6 model	
Non-supercharged	
Left side	10,000 ohms
Right side	27,000 ohms
Supercharged	
Left side	10,000 ohms
Right side	17,000 ohms
5.0 litre V8 models	25,000 ohms
5.7 litre Gen III and 6.0 litre Gen IV models	700 ohms

Alternator

Brush minimum length
- 3.8 litre V6 and 5.0 litre V8 models ..... 3.8 mm
- 3.6 litre V6, 5.7 litre Gen III and 6.0 litre Gen IV V8 models ..... 5 mm

Rotor slip ring resistance (approximate)
- 3.8 litre V6 models..... 2.47 to 2.73 ohms
- 3.6 litre V6, 5.7 litre Gen III and 6.0 litre Gen IV V8 .....2.1 ohms
- 5.0 litre V8 models..... 2.23 to 2.46 ohms

Stator winding resistance (approximate)
- 3.8 litre V6 models.....0.058 to 0.063 ohms
- 3.6 litre V6, 5.7 litre Gen III and 6.0 litre Gen IV V8 ..... 0.098 ohms
- 5.0 litre V8 models..... 0.015 ohms

Rectifier diode forward current rating..... 35 amps

Slip ring
- Diameter (minimum)
  - 3.8 litre V6 and 5.0 litre V8 models ..... 26.7 mm
  - 3.6 litre V6, 5.7 litre Gen III and 6.0 litre Gen IV V8 ..... 22.1 mm
- Out-of-round (maximum)
  - 3.8 litre V6 and 5.0 litre V8 models ..... 0.06 mm
  - 3.6 litre V6, 5.7 litre Gen III and 6.0 litre Gen IV V8 .....Not specified
- Runout (maximum)
  - 3.8 litre V6 and 5.0 litre V8 models ..... 0.45 mm
  - 3.6 litre V6, 5.7 litre Gen III and 6.0 litre Gen IV V8 .....Not specified

Starter motor

3.8 litre V6 models
- Armature endplay.....0.05 to 0.30 mm
- Brush minimum length
  - VT and VX.....7 mm
  - VY .....8 mm
- Field coil winding resistance (VT and VX).....1 meg-ohm or more
- Commutator out-of-round limit ..... 0.1 mm
- Armature lamination out-of-round limit (VT and VX)..... 0.5 mm
- Commutator minimum diameter ..... 31.2 mm
- Maximum current
  - VT and VX .....125 amps @ 11.5 volts
  - VY .....65 amps @ 12 volts

3.6 litre V6 models
- Maximum current.....65 amps @ 12 volts

5.0 litre V8 models
- Armature endplay.....0.05 to 0.30 mm
- Brushes
  - Minimum length.....13 mm
  - Spring tension .....15 to 17 N
- Field coil winding resistance.....1 meg-ohm or more
- Commutator out-of-round limit ..... 0.05 mm
- Commutator lamination out-of-round limit .... 0.5 mm
- Commutator minimum diameter ..... 33.5 mm
- Maximum current.....70 amps @ 12 volts

5.7 litre Gen III and 6.0 litre Gen IV V8 models
- Maximum current.....90 amps @ 11 volts
- Brush minimum length..... 7 mm
- Commutator out-of-round limit ..... 0.1 mm
- Commutator minimum diameter ..... 28.8 mm

Torque specifications

	Nm
VT and VX 3.8 litre V6 and 5.0 litre V8 alternator	
B+ terminal nut	8
Drive end housing bearing screws	3
Drive pulley nut	54 to 68
Rectifier retaining screw	
V6 models	2
V8 models	3
Regulator/brush assembly screws	2
Through-bolt	5
VY 3.8 litre V6 and 5.7 litre Gen III V8 alternator	
B+ terminal nut	13 to 18
Drive end housing bearing screws	2 to 5
Drive pulley nut	99 to 137
Rectifier retaining screw	2 to 5
Regulator/brush assembly screws	2 to 5
Through-bolt	4
3.6 litre V6 alternator	
B+ terminal nut	5 to 12
Mounting studs	10 to 15
Mounting nuts	15 to 20
Mounting bracket bolts	40 to 60
Starter motor	
Solenoid drive end screw	6
50 terminal nut	9
Dust cover screw	2
Through-bolt	8
Pole shoe screws	
1997 and 1998 models	30 to 60
1999 series II models	25
Mounting bolts	40 to 60
30 terminal nut	10

1 General information

Warning 1: *Because of the very high voltage generated by the ignition system, extreme care should be taken whenever an operation involving ignition components is performed. This not only includes the distributor, coil(s), module and spark plug wires, but related items that are connected to the systems as well, such as the plug connections, tachometer and testing equipment.*

Warning 2: *Some models covered by this manual are equipped with airbags. These models are identified by a notice on the driver's door and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires.*

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery.*

3.8 litre V6 engines are equipped with the distributorless Direct Ignition System (DIS). This system shares many components

with other more common ignition systems, such as the ignition switch, battery, coils, primary (low tension) and secondary (high tension) wiring circuits and spark plugs. Ignition timing is computer controlled and non-adjustable.

3.6 litre V6 engines use a single ignition coil mounted directly onto the spark plug. This coil type is called a pencil coil because of its narrow structure. This type of coil negates the need for high tension leads and the spark plugs will last for 100,000 kms. The coils design is such that it is not possible to check coil primary or secondary resistance as can be done with a conventional ignition coil. Each ignition coil is fully controlled by the PCM, including ignition timing.

5.0 litre V8 engines use a more conventional ignition system. A distributor and external coil are mounted at the rear of the engine. The distributor contains a Hall effect unit which informs the PCM (Powertrain Control Module) of engine speed and crankshaft position. An ignition module is secured to the left inner fender panel. Ignition timing is controlled by the PCM but the base timing can be adjusted by rotating the distributor. Normally, adjustments are not necessary.

Gen III and Gen IV V8 engines use a single ignition coil for each cylinder, mounted on top of the rocker cover with a short high tension lead to the spark plug. Each ignition coil is fully controlled by the PCM, including ignition timing. The coils design is such that it is not possible to check coil primary or secondary resistance as can be done with a conventional ignition coil. Each ignition coil is fully controlled by the PCM, including ignition timing.

The charging system consists of a belt-driven alternator with an integral voltage regulator and the battery. These components work together to supply electrical power for the ignition system, the lights and all accessories.

2 Battery - emergency jump starting

Refer to the *Booster battery (jump) starting* procedure at the front of this manual.

3 Battery - removal and refitting

Warning: *Hydrogen gas is produced by the battery, so keep open flames and lighted cigarettes away from it at all times. Always wear eye protection when working around a battery. Rinse off spilled electrolyte immediately with large amounts of water.*

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery.*

REMOVAL

1 The battery is located in the engine compartment.

2 Detach the cables from the negative and positive terminals of the battery.

Caution: *To prevent arcing, disconnect the negative (-) cable first, then remove the positive (+) cable.*

3 Remove the hold-down clamp bolt and the clamp from the battery carrier.

4 Carefully lift the battery from the carrier.

Warning: *Always keep the battery in an upright position to reduce the likelihood of electrolyte spillage. If you spill electrolyte on your skin, rinse it off immediately with large amounts of water.*

REFITTING

Note: *The battery carrier and hold-down clamp should be clean and free from corrosion before refitting the battery. Make certain that there are no parts in the carrier before refitting the battery.*

5 Set the battery in position in its carrier. Don't tilt it.

6 Refit the hold-down clamp and bolt. The bolt should be snug, but overtightening it may damage the battery case.

7 Refit both battery cables, positive first, then the negative.

Note: *The battery terminals and cable ends should be cleaned prior to connection (see Chapter 1).*

4 Battery cables - check and renewal

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery.*

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

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

3 If only the positive cable is to be renewed, be sure to disconnect the negative cable from the battery first.

4 Disconnect and remove the cable. Make sure the new cable is the same length and diameter.

5 Clean the threads of the starter or earth connection with a wire brush to remove rust and corrosion. Apply a light coat of petroleum jelly to the threads to ease refitting and prevent future corrosion.

6 Attach the cable to the starter or earth connection and tighten the mounting nut securely.

7 Before connecting the new cable to the battery, make sure it reaches the terminals without having to be stretched.

8 Connect the positive cable first, followed by the negative cable. Tighten the nuts and apply a thin coat of petroleum jelly to the terminal and cable connection.

Note: *If the cable terminals at the battery are the only parts that are corroded or damaged, they can be renewed without having to purchase an entire cable assembly. Follow the procedure above. Cut off the old terminal, remove about two centimetres of insulation from the end of the cable and attach the new end. Finish as in the procedure above.*

5 Ignition system - general information

Warning: *Because of the very high voltage generated by the ignition system, extreme care should be taken whenever an operation involving ignition components is performed. This not only includes the distributor, coil(s), module and spark plug wires, but related items that are connected to the systems as well, such as the plug connections, tachometer and testing equipment.*

3.8 litre V6 engines are equipped with a distributorless Direct Ignition System (DIS). Timing is computer-controlled and non-adjustable.

The V6 DIS system includes a coil pack (three individual coils), an ignition module, a crankshaft reluctor ring, a magnetic crankshaft position sensor and the PCM. The ignition module is located under the coil pack and is connected to the PCM.

The magnetic crankshaft sensor protrudes through the engine block, close to the balancer interrupter ring. The interrupter ring is a special disc on the back of the crankshaft balancer, which acts as a signal generator for the ignition timing.

The system uses control wires from the PCM, just like conventional distributor systems. The PCM controls timing using crankshaft position, engine rpm, engine temperature and manifold absolute pressure (MAP) sensing.

5.0 litre V8 engines use an ignition system which is more traditional. Although all timing adjustments are still made by the PCM, the distribution of the spark is handled by the camshaft-driven distributor. A remote coil and ignition module are activated by instructions from the PCM to provide energy to the distributor.

3.6 litre V6, 5.7 litre Gen III and 6.0 litre Gen IV V8 models are equipped with a distributorless ignition system. The ignition system consists of the battery, eight ignition coils (one per cylinder), spark plug wires, on the V8 models, spark plugs, camshaft position sensor, crankshaft position sensor and the Powertrain Control Module (PCM). The coils design is such that it is not possible to check coil primary or secondary resistance as can be done with a conventional ignition coil.

On all models, the PCM controls the ignition timing and spark advance characteristics for the engine. The ignition timing is not adjustable.

The crankshaft position sensor produces a signal voltage to indicate crankshaft position and crankshaft speed. This signal is used by the Powertrain Control Module (PCM) to control the ignition system and ignition timing.

The camshaft position sensor operation is similar to a crankshaft position sensor, but produces only one pulse per camshaft revolution. The camshaft position sensor signal is not essential to engine operation. The PCM uses the camshaft position sensor signal for fuel synchronization and misfire detection.

The ignition system is also equipped with two knock sensors to detect detonation, or spark knock (usually caused by the use of sub-standard fuel). The system uses a knock sensor in conjunction with the Powertrain Control Module (PCM) to control spark timing. If a knock signal is received, the PCM will retard the timing until the knock is eliminated. The knock sensor system allows the engine to use maximum spark advance without spark knock, which improves driveability and fuel economy.

6 Ignition system - check

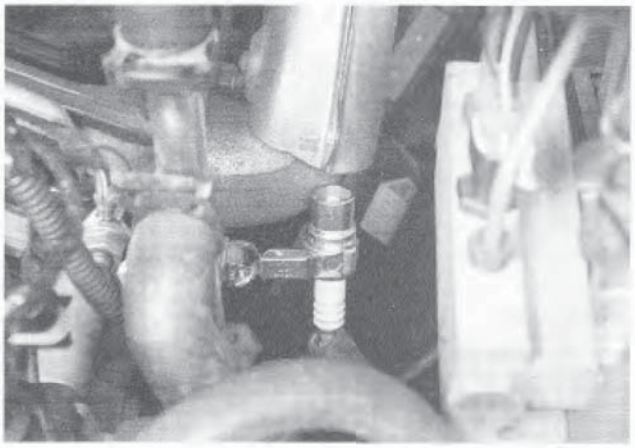
Warning 1: *Because of the very high voltage generated by the ignition system, extreme care should be taken whenever an operation is performed involving ignition components. This not only includes the coils, control module and spark plug wires, but related items connected to the system as well, such as the plug connections, tachometer and any test equipment.*

Warning 2: *The following procedure requires the engine to be cranked during testing, make sure the meter leads, loose clothing, long hair, etc. are away from the moving parts of the engine (drivebelt, cooling fan, etc.) before cranking the engine.*

GENERAL CHECKS

Refer to illustration 6.3

1. Check all ignition wiring connections for tightness, cuts, corrosion or any other signs of a bad connection. A faulty or poor connection at a spark plug could also result in a misfire. Also check for carbon deposits inside the spark plug boots. Remove the spark plugs, if necessary, and check for fouling.
2. Check for ignition and battery supply to the PCM. Check the ignition fuses (see Chapter 12).
3. Use a calibrated ignition tester to verify adequate available secondary voltage (25,000 volts) at the spark plugs (see illustration). Using an ohmmeter, check the resistance of the spark plug wires. Each wire should measure less than the figure listed in the Specifications in this Chapter.
4. On 5.0 litre V8 engines, use the same ignition tester to verify that there is correct secondary voltage at the coil wire at the centre of the distributor. If there is a good spark at the coil wire, yet none at the spark plugs, check for a bad distributor cap or rotor. The spark plug wires may also be faulty.
5. Check to see if the fuel pump and relay are operating properly (see Chapter 4). The fuel pump should activate for two seconds when the ignition key is cycled ON. Refit an injector test light and monitor the blinks as the injector voltage signal pulses (see Chapter 4, *Fuel injection system - check*).



6.3 To use a calibrated ignition tester (available at most auto parts stores), simply disconnect a spark plug wire, attach the wire to the tester, clip the tester to a convenient earth and operate the starter - if there's enough power to fire the plug, sparks will be visible between the electrode tip and the tester body

3.8 LITRE V6 ENGINE RUNS BUT MISFIRES

Refer to illustration 6.6

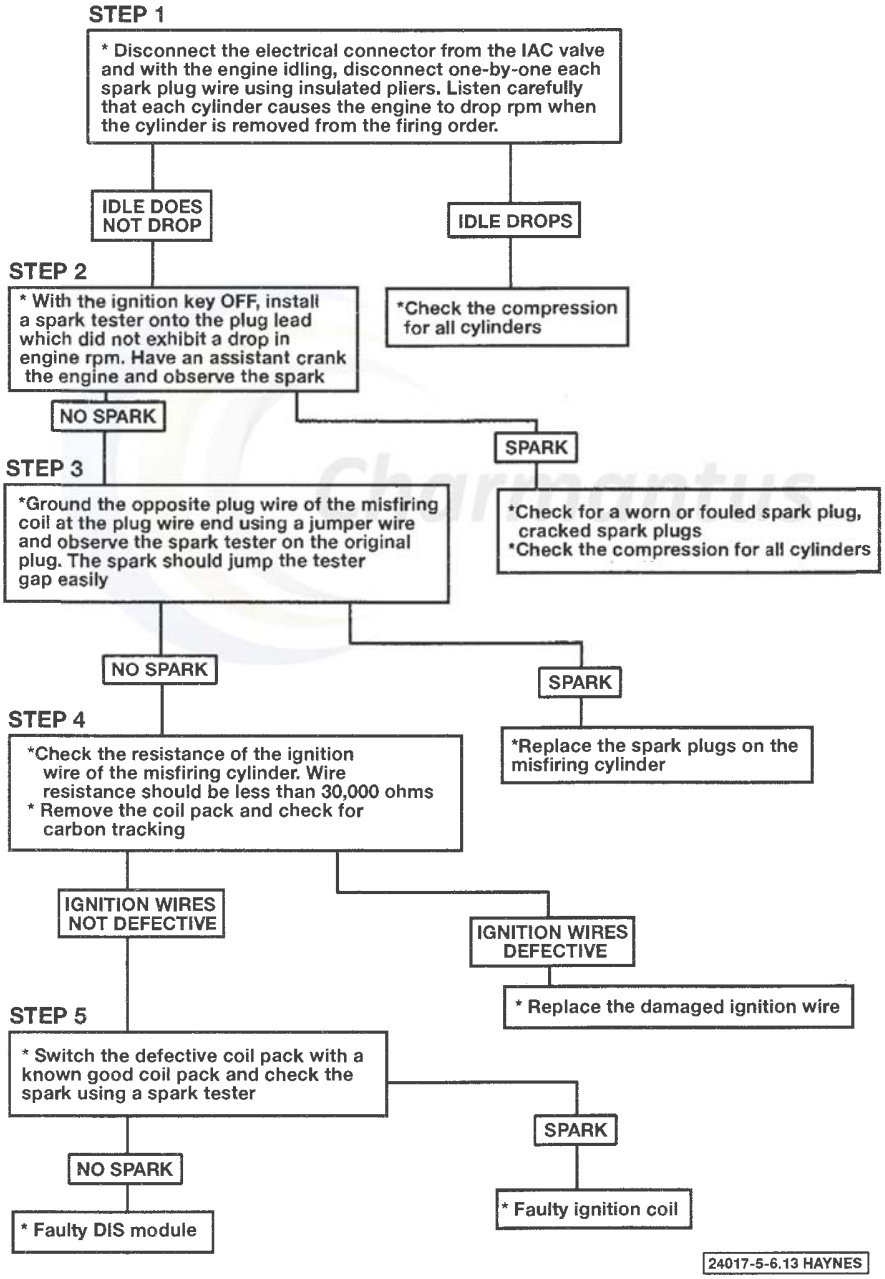
6 **Test 1:** If the engine misfires at idle, perform the first test indicated in the accompanying RUNS BUT MISFIRES flow chart (see illustration). If the engine has a NO START condition, proceed to that diagnostic chart (see illustration 6.17).

7 **Test 2:** Use a spark tester to verify adequate available secondary voltage (25,000 volts) at the spark plugs (see illustration 6.3).

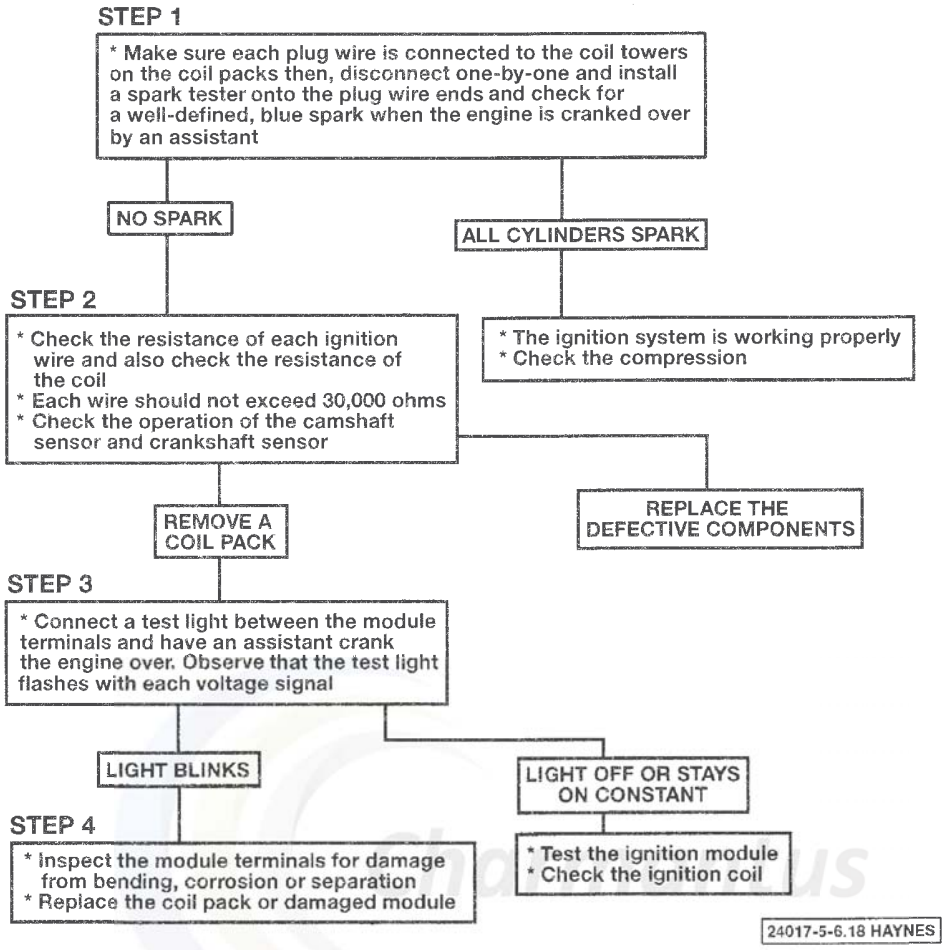
8 **Test 3:** On V6 engines, if the spark jumps the test gap at the spark plug after earthing the opposite plug wire, it indicates excessive resistance in the plug which was bypassed. A faulty or poor connection at that plug could also result in a misfire condition. Also check for carbon deposits inside the spark plug boot.

9 **Test 4:** If carbon tracking is evident, renew the coil(s) and be sure that the plug wires relating to that coil are clean and tight. Excessive wire resistance or faulty connections could cause damage to the coil.

10 **Test 5:** If a no spark condition disappears when the coil is switched for another coil, the original coil is faulty. If not, the ignition module is the cause of the no spark condition. This test can also be performed by substituting a known good coil for the one causing the no spark condition.



6.6 Diagnostic flow chart for a MISFIRING engine (V6 only)



6.17 Diagnostic flow chart for checking a NO START condition (V6 only)

5.0 LITRE V8 ENGINE RUNS BUT MISFIRES

11 Use a spark tester to verify adequate available secondary voltage (25,000 volts) at the spark plugs (see illustration 6.3). If sparks occur, sufficient voltage is reaching the plugs to fire them. (Repeat the test on all plug wires). If a bright blue spark is evident, then the spark plugs may be defective.

12 If no sparks or intermittent sparks occur, remove the distributor cap and check the inside of the cap and the rotor as described in Chapter 1. If moisture is present, dry the cap and repeat the tests.

13 If no sparks occur, use a spark tester to verify adequate available secondary voltage (25,000 volts) at the ignition coil. (If no spark tester is available, hold the end of the wire about 6 mm from a good engine earth).

14 If sparks now occur, the distributor cap, rotor or spark plug wires may be defective.

15 If no sparks occur, check the primary wire connections at the coil and at the ignition module. Make sure they're clean and tight. Check for voltage at the coil. Repeat the test.

16 If there is still no spark, the coil-to-cap wire may be bad. Check its resistance with an ohmmeter - it should be less than 7,000 ohms. If a known good wire doesn't make any difference in the test results, the ignition coil may be defective.

NO START CONDITION, 3.8 LITRE V6 ENGINE

Refer to illustrations 6.17 and 6.19

17 Refer to the NO START test (see illustration). **Test 1** verifies the ability of the system to produce at least 25,000 volts.

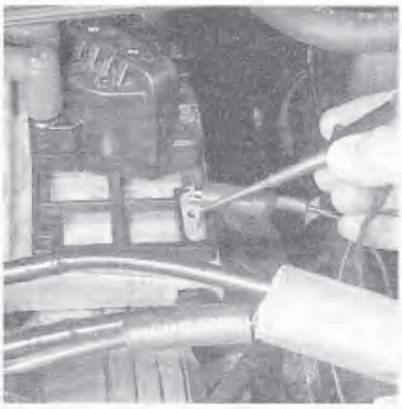
18 **Test 2:** No spark on one cylinder may be caused by an open plug wire or secondary winding. Both wires related to a coil and the secondary winding resistance should therefore be checked. Resistance readings over the upper limit, but not infinite, will probably not cause a no start but may cause an engine miss under certain conditions.

19 **Test 3** tests the triggering circuit in the ignition module. A blinking test light indicates the module is triggering (see illustration).

20 **Test 4:** A slowly blinking light at this point indicates the PCM is not seeing a crank sensor signal (see Chapter 6). At this point, the problem is in the camshaft or crankshaft sensor(s), sensor circuits or the ignition module.

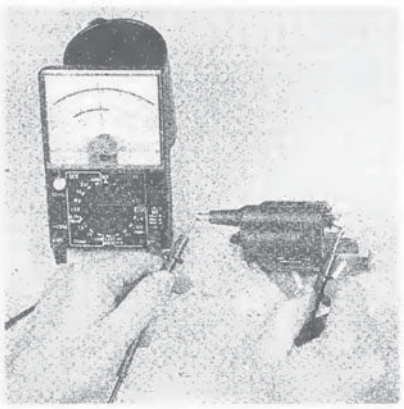
> ***Note:*** *Refer to Chapter 6 for additional information and testing procedures for the camshaft sensor and the crankshaft sensor.*

21 Turn the ignition ON (engine not running) and listen for the fuel pump within the first two seconds. If the fuel pump runs, the fuse is okay.



6.19 Connect a test light between the coil terminals on the ignition module and watch for a blinking light when the engine is cranked

7.2a Checking the coil pack secondary resistance on the V6 engine



7.2b Connect the ohmmeter to the high tension wire and the negative primary terminal to check the secondary resistance on a 5.0 litre V8 coil

7.3a Checking the coil pack primary resistance on a V6 engine

7.3b Connect the ohmmeter to the positive and negative terminals to check the primary resistance on a 5.0 litre V8 coil

7 Ignition coil - check, removal and refitting

Note 1: *V6 engines use a coil pack consisting of three individual coils (each coil fires two cylinders).*

Note 2: *3.6 litre V6, Gen III and Gen IV V8 engines use eight individual coils. (each coil fires one cylinder).*

Note 3: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery.*

CHECK

V6 and 5.0 litre V8 models

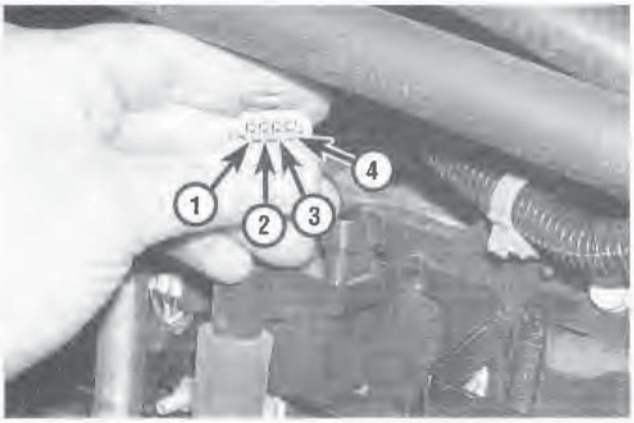
Refer to illustrations 7.2a, 7.2b, 7.3a and 7.3b

1 Refer to Section 6 and perform the simple ignition system checks (all models).

2 Use an ohmmeter and check secondary resistance for the coil (5.0 litre V8 models), or each coil of the coil pack (V6 models) (see illustrations). Refer to the Specifications listed in this Chapter for the correct amount of resistance.

3 Next, check the primary resistance for the coil or each coil of the coil pack (see illustrations). Refer to the Specifications listed in this Chapter for the correct amount of resistance.

7.4 Disconnect an ignition coil electrical connector (arrow) and check for battery power at the pink wire terminal of the connector



7.5 Using a test light connected to the positive battery terminal, check for a trigger signal at the ignition control terminal

1 12-volt supply
2 Ignition control (from PCM)
3 Reference low
4 Ground

3.6 litre V6, 5.7 litre Gen III and 6.0 litre Gen IV V8 models

Refer to illustrations 7.4 and 7.5

4 Check for battery voltage to the ignition coils from the ignition switch. Attach a 12 volt test light to the battery negative (-) terminal or other good earth. Disconnect the electrical connector from one of the ignition coils and check for power at the pink wire terminal (see illustration). Battery voltage should be available with the ignition key "ON". If there is no battery voltage present, check the wiring and/or circuit between the under bonnet electrical centre and ignition coil connector (don't forget to check the fuses). Also check the black wire terminal for continuity to battery ground.

5 Check for a trigger signal from the PCM. Attach the lead of a test light to the positive battery terminal and touch the probe of the test light to the ignition control circuit terminal (see illustration). Crank the engine. The test light should blink with the engine cranking if a trigger signal is present. Check each coil, if necessary. If a trigger signal is present at the coil, the power and ground circuits are good and there is no spark, replace the ignition coil. If a trigger signal is not present, check the crankshaft position sensor (see Chapter 6). If the crankshaft position sensor is good, check the circuits from the coil to the PCM. If the circuits are good, have the PCM checked by a dealer service department or other qualified repair shop.

Note: *Refer to the wiring diagrams at the end of Chapter 12 for wire colour identification for testing and additional information on the circuits.*

REMOVAL

3.8 litre V6 models

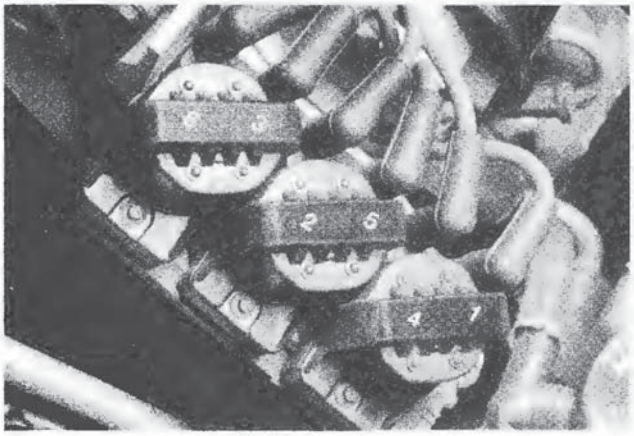
Refer to illustrations 7.7 and 7.8

6 Ensure the ignition is Off and unplug the electrical connectors from the module.

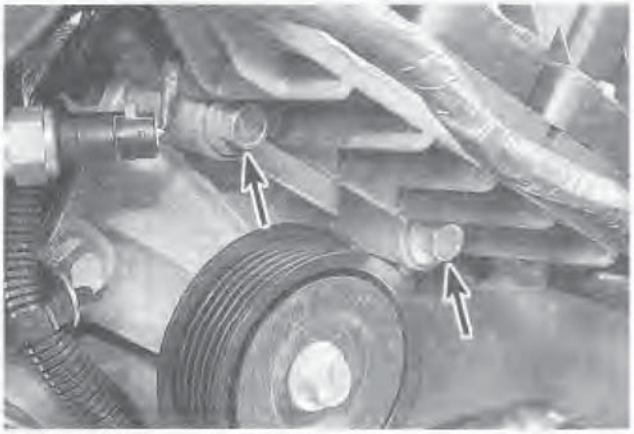
7 If the plug wires are not numbered, label them and detach the plug wires at the coil assembly (see illustration).

8 Remove the module/coil assembly mounting bolts and lift the assembly from the vehicle (see illustration).

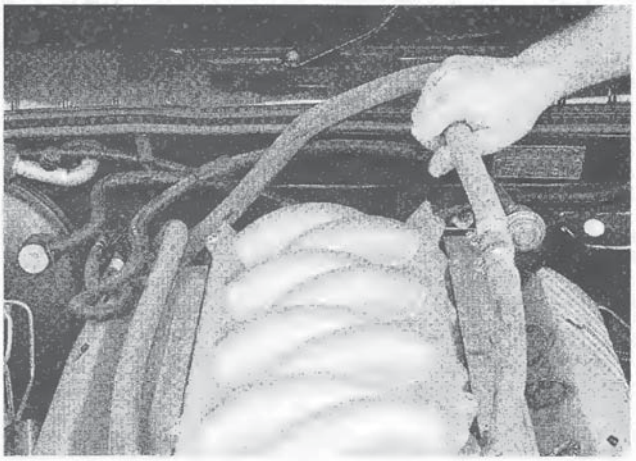
Note: *The ignition coils can be removed from the module separately for renewal.*



7.7 Original equipment coils are numbered with their corresponding cylinder numbers stamped on the top. If you renew one, be sure to renumber it



7.8 Remove the bolts (arrows) and lift the coil packs and module from the engine as a complete assembly (V6 engine)



7.15 The heater hose must be held aside on 5.0 litre V8 engines whenever you are working on the coil or distributor

3.6 litre V6 models

9 Ensure the ignition is Off and unplug the electrical connectors from the ignition coils.

10 Loosen the ignition coil bolts and pull the coils from the rocker cover.

> ***Note:*** *The coil bolts are captive bolts. They will remain in the coil housing.*

5.0 Litre V8 models

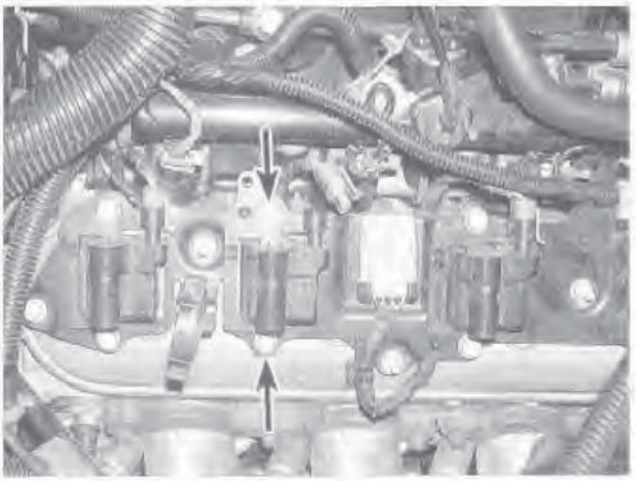
Refer to illustration 7.15

11 Relieve the fuel system pressure (refer to Chapter 4).

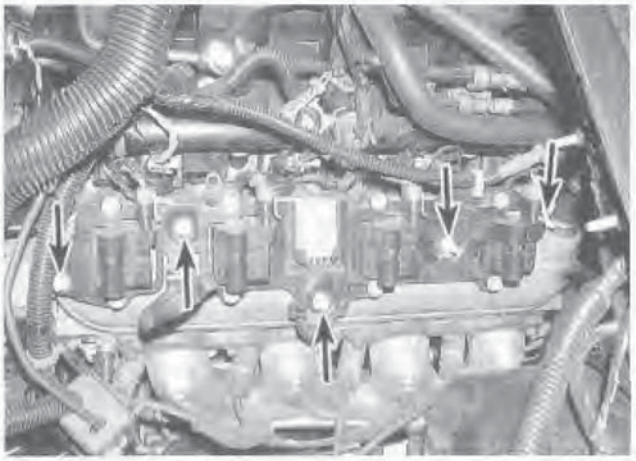
12 Remove the front and valve cover engine trim covers.

13 Disconnect the fuel supply hose from the fuel rail (refer to Chapter 4). It has a white tag to identify it.

14 Disconnect the spark plug wires from the spark plugs. Label them as you do so to avoid confusion later. Disconnect the wires from the retainers at the valve covers.



7.23 Remove the ignition coil mounting screws (arrows)



7.22 Remove the ignition coil bracket bolts (arrows)

15 Lift the left heater hose up and secure it out of the way (see illustration).

16 Disconnect the high tension wire from the ignition coil.

17 Remove the distributor cap with the wires attached to it.

18 Disconnect the wiring harness from the coil.

19 Unbolt and remove the coil.

5.7 Litre Gen III and 6.0 litre Gen IV V8 models

Refer to illustrations 7.22 and 7.23

20 Ensure the ignition is Off.

21 The ignition coils may be removed from each cylinder bank as a complete assembly or removed from the mounting bracket individually.

22 If removing the complete assembly, disconnect the ignition coils main electrical connector. Disconnect the spark plug wires from the spark plugs. Remove the ignition coil bracket mounting nuts/bolts and remove the assembly from the engine (see illustration).

23 If removing an individual coil, disconnect the spark plug wire from the coil. Remove the ignition coil mounting screws and remove the ignition coil from the bracket (see illustration).

REFITTING

24 Refitting is the reverse of removal.

25 When refitting the coil(s), make sure they are connected properly and that all secondary wires are clean and fully seated.

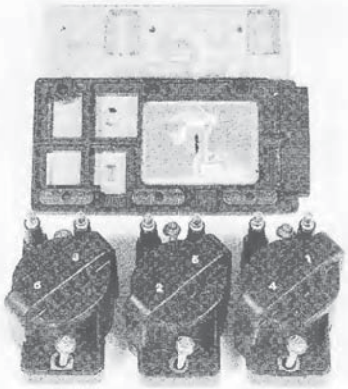
8 Electronic ignition system module - check and renewal

CHECK

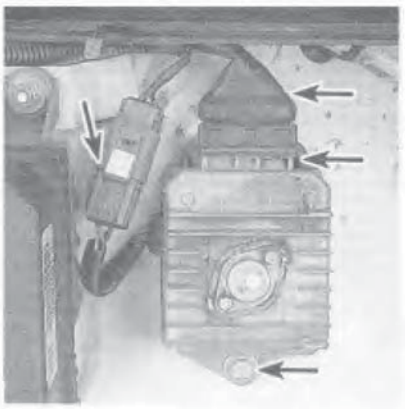
3.8 litre V6 models

> ***Caution:*** *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery.*

8.10 Pop the wiring retainer (arrow) from the V6 coil pack



8.12 The individual coils can be separated from the module in order to renew either



8.17 Disconnect the wiring connectors and remove the bolts (arrows), then detach the V8 engine module

1 First, perform the ignition system checks detailed in Section 6.
2 To check the ignition module, disconnect the electrical connectors from the ignition module.
3 With the ignition key ON (engine not running) check for battery voltage using a voltmeter at terminal P. There should be battery voltage present.

> ***Note:*** *If battery voltage is not present, check the IGNITION fuse. This might be a simple solution to a NO START condition.*

4 Next, using an ohmmeter, check the resistance of the crankshaft sensor and circuit (see Chapter 6). Probe the crankshaft sensor terminals on the sensor side of the module connector). It should read between 900 and 1,200 ohms.
5 Finally, check the output voltage signal from the crankshaft sensor. Switch the voltmeter to AC scale, backprobe the crankshaft sensor electrical terminal, crank the engine over and confirm that the voltage output is greater than 0.1 volt (100 millivolts).

> ***Note:*** *Refer to Chapter 6 for additional information and testing procedures for the camshaft sensor and crankshaft sensor.*

6 If all these tests are correct and there is no spark output at any of the coils, the ignition module is defective. In the event any of the system check findings are incorrect, diagnose the individual circuits and components.

IGNITION MODULE RENEWAL

3.8 litre V6 models

Refer to illustrations 8.10 and 8.12

7 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

8 Clearly label, then disconnect, all spark plug wires from the coil pack.
9 Unplug the 14 pin electrical connector at the module.
10 Unclip the wire retainer from the coil and module assembly (see illustration).
11 Remove the assembly attaching screws (see illustration 7.7).
12 Separate the coils from the module (see illustration).
13 Refitting is the reverse of removal. Be sure to attach the wires of the new module to the coil assembly spade terminals in exactly the same order in which they were removed.

5.0 litre V8 models

Refer to illustration 8.17

14 Turn the ignition OFF.
15 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual)*

16 Refer to Chapter 4 and remove the air cleaner housing and the inlet air duct. Handle the mass air flow sensor with care.
17 Disconnect the two wiring harnesses from the ignition module. It will be necessary to use a small screwdriver to release the locking mechanism on the connector that attaches to the body of the module and unbolt the module from the fender and remove it (see illustration).
18 Refitting is the reverse of removal.

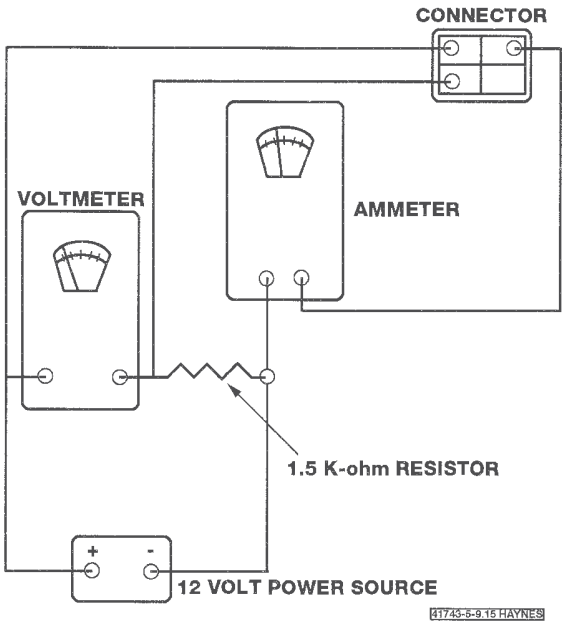
3.6 litre V6, 5.7 litre Gen III and 6.l Gen IV V8 models

19 The ignition module(s) on these engines are incorporated into each coil pack. Refer to Section 7 for ignition coil renewal procedures.

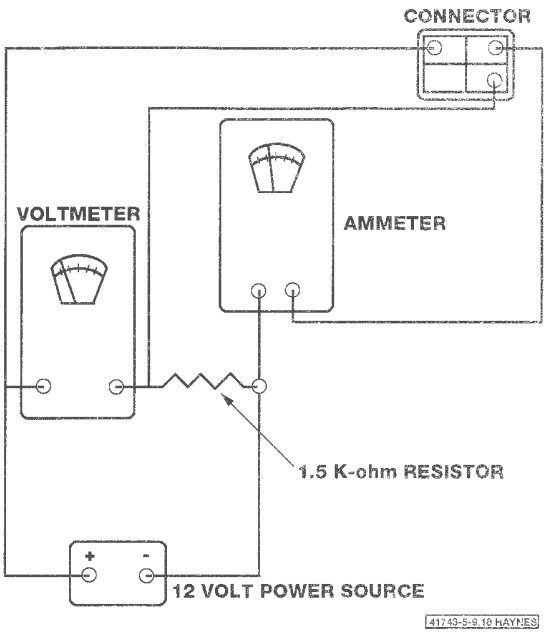
9 Distributor (5.0 litre V8 models only) - removal, check and refitting

REMOVAL

1 Disconnect the earth (-) lead from the battery.



9.15 The best method of testing the Hall effect unit in the distributor is to set up this equipment. With the components connected to a power source, rotate the distributor shaft and observe the readings on the voltmeter and the ammeter



9.18 Move the single test wire shown from the previous set-up at the distributor wiring harness to complete the test procedure

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual)*

2 Relieve the fuel system pressure (refer to Chapter 4).

3 Remove the front and valve cover engine trim covers.

4 Disconnect the fuel supply hose from the fuel rail (refer to Chapter 4).

5 Disconnect the spark plug wires from the spark plugs. Label them as you do so to avoid confusion later. Disconnect the wires from the retainers at the valve covers.

6 Lift the left heater hose up and secure it out of the way (see illustration 7.15).

7 Disconnect the high tension wire from the ignition coil.

8 Disconnect the distributor wiring harness from the distributor.

9 Remove the distributor cap with the wires attached and lay it out of the way.

10 Rotate the engine (with a ratchet or breaker bar attached to the crankshaft) to top dead centre on the compression stroke (refer to Chapter 2C). At this position, the distributor rotor will point directly at the spark plug wire terminal for cylinder number one and the timing mark on the crankshaft balancer will line up with the zero on the timing scale. Do not proceed until both of these conditions are met.

11 Using chalk or paint, mark the position of the rotor on the distributor housing.

12 Mark the exact position of the distributor housing on the engine block.

13 Remove the distributor hold-down bolt and clamp, using a crows foot or a distributor bolt spanner, if available. Lift out the distributor.

Note: *Do not allow the engine to rotate while the distributor is out. If it is rotated, you will have to reposition it at TDC on the compression stroke as described in Chapter 2C.*

TESTING

Refer to illustrations 9.15 and 9.18

14 Inspect the distributor shaft for excessive side-to-side looseness, wear, lack of lubrication and obvious damage.

15 Connect a voltmeter, a 1,500 ohm resistor and an ammeter to the distributor (see illustration).

16 Rotate the distributor shaft while observing the meter readings. The voltmeter should alternate between 0.4 volts and 11 volts as the shaft is turned. The ammeter should read less than 20 milliamps at all times.

17 If the readings are not as specified, renew the Hall effect switch in the distributor (refer to Section 10) or renew the entire distributor.

18 Reconnect the test apparatus you made in the previous Steps where it connects to the distributor harness (see illustration).

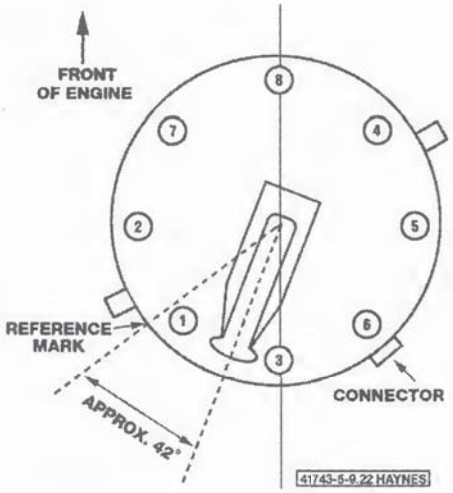
19 Repeat turning the shaft while observing the voltmeter and ammeter. Both meters should react just as in the first test. If either reads out of specifications, renew the Hall effect switch.

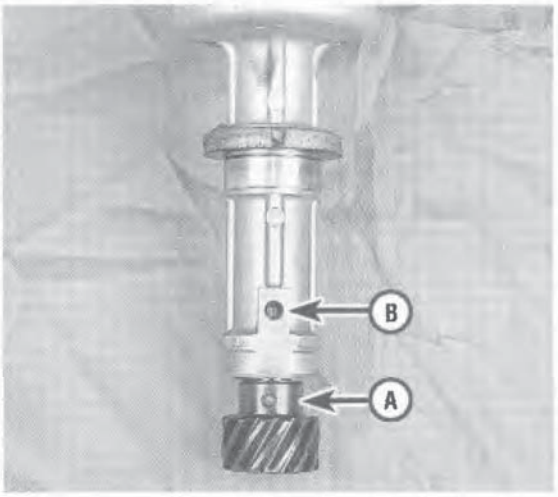
REFITTING

Refer to illustration 9.22

20 Make sure that the engine has not been rotated. It must still be at TDC on the compression stroke.

21 Line up the rotor with the mark on the body of the distributor which you made previously. (It should be aligned with the number 1 spark plug wire terminal).





9.22 The drive gear roll pin (A) must align with the oil drain hole (B) in the distributor body prior to refitting

22 Rotate the rotor approximately 42 degrees anti-clockwise so that it points midway between the terminals for cylinders number 1 and 3. In this position, the oil drain hole in the lower portion of the distributor housing should align with the roll pin for the drive gear (see illustration).

23 Insert the distributor into the engine, aligning the other marks you previously made on the distributor and the engine.

> ***Note:*** *The rotor will rotate as the distributor is lowered into the engine. When it is fully inserted, the rotor should again line up with the reference mark.*

24 Check that both sets of marks previously made align correctly.

25 The remainder of refitting is the reverse of removal.

26 Check the ignition timing (refer to Chapter 1).

10 Hall effect switch (5.0 litre V8 models only) - removal and refitting

Refer to illustrations 10.3, 10.4, 10.5 and 10.8

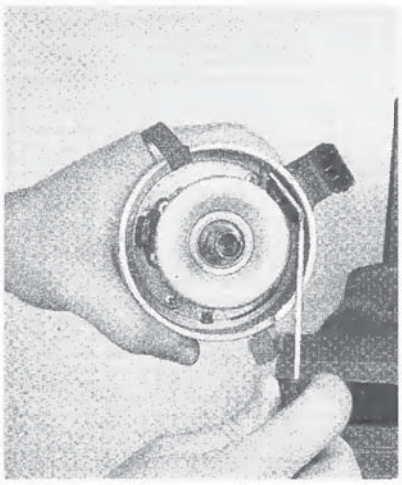
1 Remove the distributor (refer to Section 9).

2 Remove the rotor from the distributor shaft.

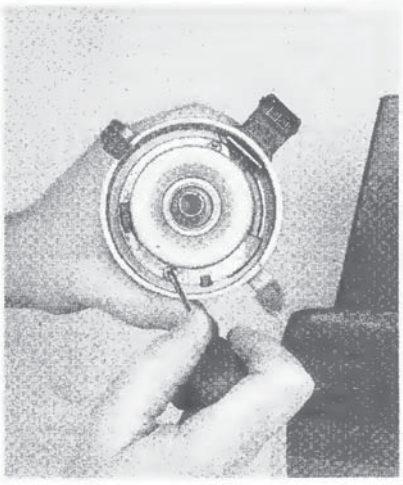
3 Prise up the clip which retains the wiring connector (see illustration). Remove the wiring connector from the distributor housing.

4 Remove the screws from the Hall effect switch (see illustration).

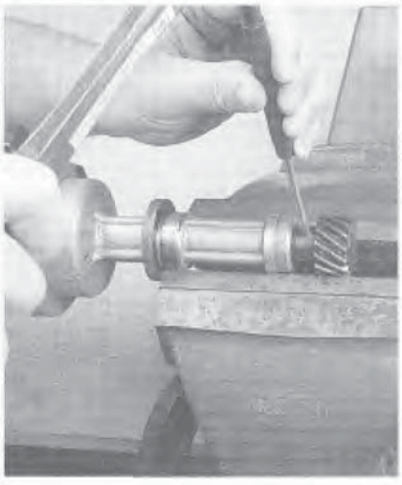
5 Place the bottom of the distributor on a block of wood and drive the roll pin from the drive gear with a hammer and a small punch (see illustration). Remove the gear and the thrust washers. Place all of the parts in order as you remove them.



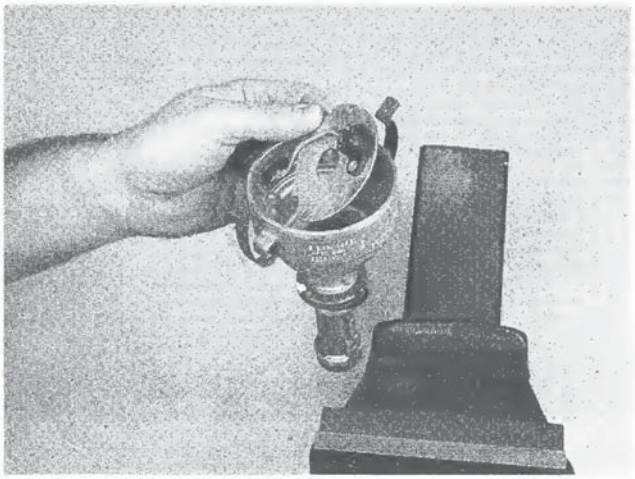
10.3 Use a screwdriver to remove the clip which secures the wiring connector housing



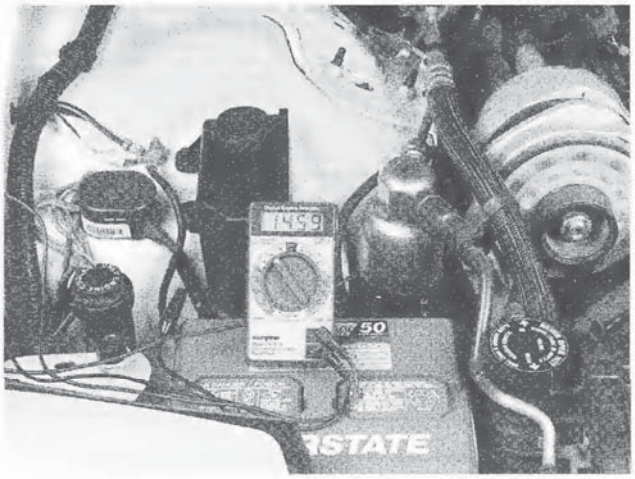
10.4 Remove the screws from the Hall effect switch



10.5 Drive the roll pin from the distributor gear using a small punch



10.8 Remove the Hall effect switch



12.3 Monitor the battery voltage after the engine is started - the voltage should be between 14 to 15 volts

6 Push the shaft from the housing.
7 Remove both external snap-rings from the shaft with snap-ring pliers.
8 Remove the Hall effect switch (see illustration).
9 Refitting is the reverse of removal.

11 Charging system - general information and precautions

The charging system consists of a belt-driven alternator with an integral voltage regulator and the battery. These components work together to supply electrical power for the ignition system, the lights and all accessories.

A 90 or 100 amp Bosch alternator is used on V6 models. V8 models use a 120 amp alternator. Both use a conventional pulley.

Because of the expense and the limited availability of parts, no alternator overhaul information is included in this manual. Normally, if a particular component of the unit has failed, there are several other parts which are likewise nearing the ends of their service lives. The amount of time spent in diagnosis of internal alternator components generally outweighs any savings in cost.

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. On all models with which this manual is concerned, the voltage regulator is contained within the alternator housing.

The charging system does not ordinarily require periodic maintenance. The drivebelt, electrical wiring and connections should, however, be inspected at the intervals suggested in Chapter 1.

Take extreme care when making circuit connections to a vehicle equipped with an alternator and note the following. When making connections to the alternator from a battery, always match correct polarity. Before using arc welding equipment to repair any part of the vehicle, disconnect the wires from the alternator and the battery terminal. Never start the engine with a battery charger connected. Always disconnect both battery leads before using a battery charger.

The charging indicator light on the dash lights when the ignition switch is turned on and goes out when the engine starts. If the light stays on or comes on once the engine is running, a charging system problem has occurred.

12 Charging system - check

Refer to illustration 12.3

1 If a malfunction occurs in the charging circuit, do not immediately assume that the alternator is causing the problem. First check the following items:

a) Make sure the battery cable connections at the battery are clean and tight.
b) The battery electrolyte specific gravity (if possible). If it is low, charge the battery.
c) Check the external alternator wiring and connections. They must be in good condition.
d) Check the drivebelt condition and tension (Chapter 1).
e) Make sure the alternator mounting bolts are tight.
f) Run the engine and check the alternator for abnormal noise (may be caused by a loose drive pulley, loose mounting bolts, worn or dirty bearings, defective diode or defective stator).

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. It should now be approximately 13.5 to 14.5 volts (see illustration).

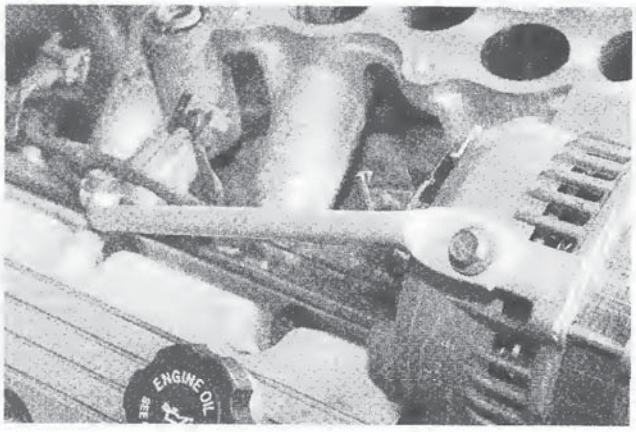
13 Alternator - removal and refitting

Refer to illustrations 13.4a and 13.4b

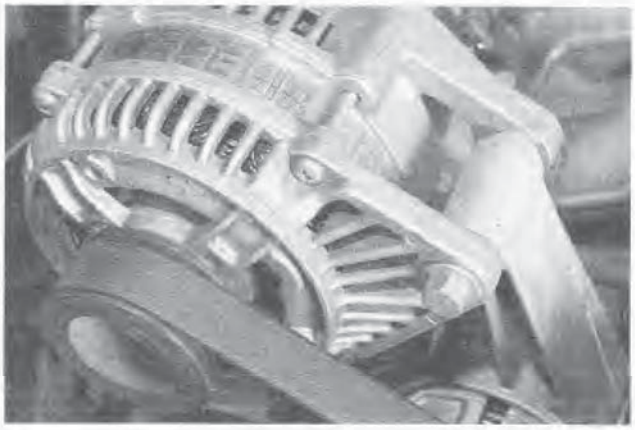
***Caution:** Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery.*

V6 AND 5.0 LITRE V8 ENGINES

1 Disconnect the earth (-) lead from the battery.



13.4a The alternator is secured by a brace which must be removed...



13.4b ...as well as the mounting bolts

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

On V6 models, remove the dress cover from the engine.

2 Clearly label, if necessary, then unplug and unbolt the electrical connectors from the alternator.

3 Remove the serpentine drivebelt on V6 models (see Chapter 1). On V8 models, loosen the mounting and adjusting bolts enough to allow the drivebelt to be slipped off.

4 Remove the alternator mounting bolts and brace (see illustrations). Remove the alternator.

***Note:** On 3.6 litre V6 engines, once the mounting nuts are removed, remove the mounting studs to allow easier removal of the alternator. The studs have hexagonal heads on them.*

5 Refitting is the reverse of removal.

5.7 LITRE GEN III AND 6.0 LITRE GEN IV V8 ENGINES

6 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual)*

7 Remove the engine cover mounting nuts (see Chapter 1).

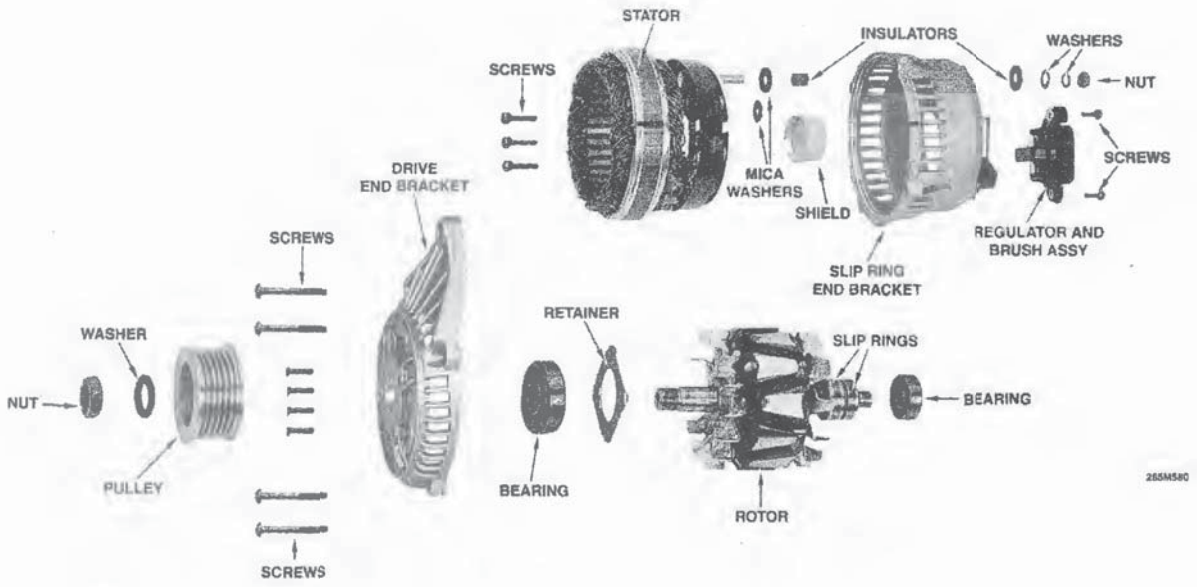
8 Remove the air inlet hose and disconnect the airflow meter electrical connection.

9 Remove the PCM heat shield and air filter housing (see Chapter 4).

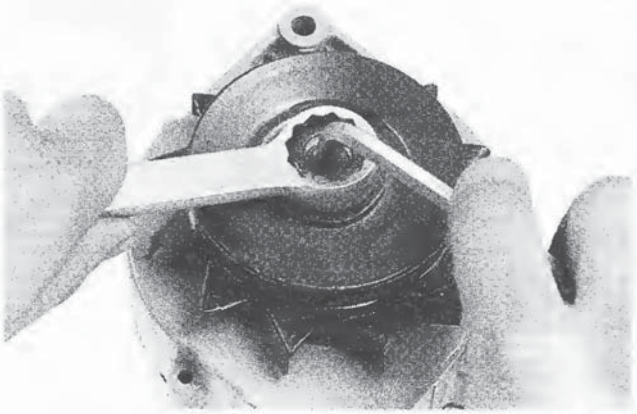
10 Use a 15 mm spanner to rotate the drivebelt tensioner anti-clockwise and remove the belt (see Chapter 1).

11 Remove the power steering reservoir and hold it to the side.

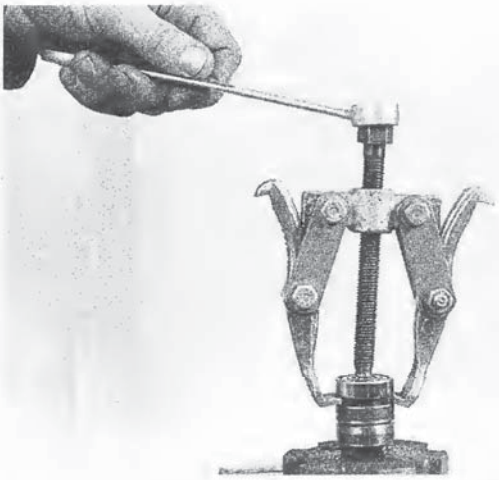
12 Disconnect the electrical connections to the alternator.



14.1 Alternator - exploded view



14.4 Because the nut is recessed, you will need to use a deep socket with an external hex and spanner to break it loose while locking the shaft from turning with an Allen wrench



14.8 A two-jaw puller can be used to remove the slip ring end bearing

13 Remove the front three through bolts and one rear mounting bracket bolt.

14 Carefully remove the alternator from the bracket and up between the radiator and engine.

15 Refitting is the reverse of removal.

14 Alternator overhaul

Refer to illustrations 14.1, 14.4, 14.8, 14.9, 14,11, 14.12, 14.14, 14.16a and 14.16b

> ***Note:*** *Special tools are needed to overhaul an alternator. These tools include an ohmmeter, soldering gun and special pullers and installers. Before disassembling the alternator, check the availability and prices of overhaul kits and also the prices of new and rebuilt alternators. Often, you'll find it easier - and sometimes less expensive - to obtain a rebuilt unit.*

14.9 The connections must be desoldered before the stator can be removed from the rectifier. Use needle-nose pliers as a heat sink to keep from over-heating the assembly

1 Remove the screws and detach the regulator/brush assembly mounted under the regulator on the rear of the alternator (see illustration). Make sure the B+ terminal wire is disconnected or damage to the B+ rail could result.

2 Scribe or paint a line across the alternator housing to ensure correct reassembly.

3 Remove the housing through-bolts.

4 Remove the pulley by inserting a deep 24 mm socket with an external hex over the pulley bolt, then using an 8 mm Allen wrench to lock the pulley so a 24 mm spanner can be used to unscrew the socket hex and nut (see illustration).

5 Remove the four bearing plate retaining screws and push the shaft and bearing assembly out of the drive end frame.

> ***Caution:*** *Do not use a press to remove the rotor from the housing; this will damage the bearing plate and drive end housing.*

6 Carefully separate the end frames.

7 A special tool (Bosch tool 9981 066 601) is required to remove the drive end housing bearing. Consequently, it is best to take the assembly to a properly equipped shop for this procedure.

8 The slip ring end bearing can be removed using a two jaw puller (see illustration). Use a hammer and socket of the same diameter as the bearing inner race to tap the new bearing into place.

9 The stator must be desoldered for removal from the rectifier assembly.

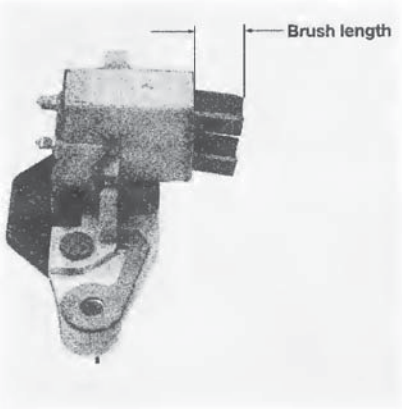
> ***Note:*** *Do not apply heat to the solder joint for more than five seconds.*

Clamp a pair of needle-pliers next to the solder joint to act as a heat sink and when the solder begins to melt, detach the wires by twisting slightly and pulling up (see illustration).

10 If you remove the rectifier, take note of any spacers or insulators behind the plate.

11 After the alternator has been completely disassembled, clean all parts with electrical contact cleaner. Do not use

14.11 Check for worn or damaged parts such as these worn out slip rings



14.12 Check the brush length in a normal rest position (springs uncoiled)

14.14 Check for continuity between slip rings with an ohmmeter. There should be no continuity between either slip ring and the rotor shaft

degreasing solvents; they can damage the electrical parts. Look for cracks in the case, burned spots and parts exhibiting signs of wear or other damage (see illustration). Renew parts as necessary.

12 Measure the length of the brushes in the regulator assembly and compare this measurement to the one listed at the beginning of this Chapter (see illustration). If the brushes are worn, unsolder the connections, then bend the retainers back and remove the brushes and springs. If the springs are discoloured or damaged in any way, renew them.

13 Assemble the new brushes and springs and insert them into the regulator. Pull the brush leads through the tabs until the brushes protrude 12 mm from the holder. Bend the tabs down and solder the leads to the connections.

14 With an ohmmeter, check the rotor slip rings for opens and grounds (see illustration). Renew the rotor or obtain a rebuilt alternator if either condition is present.

15 If the rotor checks out OK, clean the slip rings with 400 grit or finer polishing cloth.

16 Check the stator for opens and grounds (see illustrations). Renew the stator or obtain a rebuilt alternator if either condition is present.

17 Check each diode or diode trio and rectifier bridge. Connect an ohmmeter between each diode terminal and the diode case, then reverse the ohmmeter leads. If there is one high and one low reading the diode is OK. If the readings are about the same, the diode is bad and the rectifier will have to be renewed.

18 Assembly is the reverse of disassembly.

15 Starting system - general information

The function of the starting system is to crank the engine. The starting system is composed of a starter motor, solenoid and

14.16a Check for continuity between each of the stator terminals...

14.16b ...there should be no continuity between the stator terminals and the frame - if there's an open or short in the stator windings, the stator should be renewed

battery. The battery supplies the electrical energy to the solenoid, which then completes the circuit to the starting motor, which does the actual work of cranking the engine.

The solenoid and starter motor are mounted together at the lower left side of the engine. No periodic lubrication or maintenance is required.

The electrical circuitry of the vehicle is arranged so that the starter motor can only be operated when the clutch pedal is depressed (manual transmission) or the transmission selector lever is in Park or Neutral (automatic transmission).

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 cranking can cause overheating, which can seriously damage the starter.

Because of the expense and the limited availability of parts, overhauling the starter yourself is not recommended. Normally, if a particular component of the unit has failed, there are several other parts which are likewise nearing the ends of their service lives. The amount of time spent in diagnosis of internal starter components generally outweighs any savings in cost.

16 Starter motor - testing in vehicle

1 If the starter motor does not turn at all when the switch is operated, make sure that the shift lever is in Neutral or Park (automatic transmission) or that the clutch pedal is depressed (manual transmission).

2 Make sure that the battery is charged and that all cables, both at the battery and starter solenoid terminals, are secure.

3 If the starter motor spins but the engine is not cranking, the overrunning clutch in the starter motor is slipping and the motor must be removed from the engine for renewal.

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.

> ***Note:*** *Before diagnosing starter problems, make sure the battery is fully charged.*

5 If the solenoid plunger cannot be heard when the switch is actuated, the solenoid itself is defective or the solenoid circuit is open.

6 To check the solenoid, connect a jumper lead between the battery (+) and the "S" terminal on the solenoid. If the starter motor now operates, the solenoid is OK and the problem is in the ignition switch, neutral start switch or in the wiring.

7 If the starter motor still does not operate, remove the starter/solenoid assembly for renewal or disassembly, 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 clean and 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 stop the engine, disconnect the coil wire from the distributor cap and earth it on the engine.

10 Connect a voltmeter positive lead to the starter motor terminal of the solenoid, then connect the negative lead to earth.

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 9 volts or more, with the starter motor turning at normal cranking speed, is normal. If the reading is 9 volts or more but the cranking speed is slow, the motor is faulty. If the reading is less than 9 volts and the cranking speed is slow, the solenoid contacts are probably burned.

17 Starter motor - removal and refitting

Refer to illustration 17.5

1 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual)*

2 Raise the front of the vehicle and support it securely on jackstands.

3 On V8 models, it is necessary to remove the left exhaust pipe (5.0 litre engines) and the right side exhaust pipe on (5.7 litre engines). Disconnect it from the catalytic converter and the exhaust manifold, then lower it and remove it.

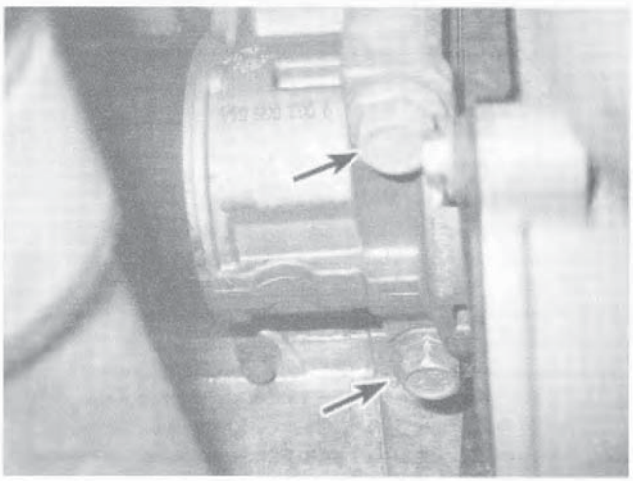
4 From under the vehicle, disconnect the solenoid wire and battery cable from the terminals on the solenoid (if possible).

5 Remove the starter motor bolts (see illustration).

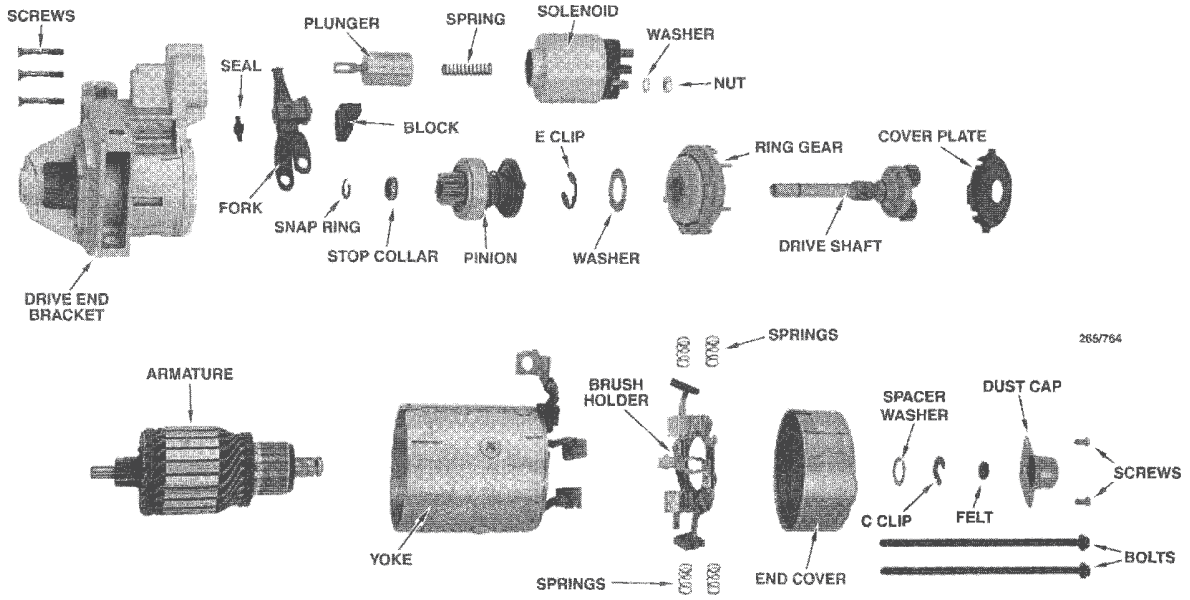
6 Remove the starter motor. If it was not possible to disconnect all wiring in Step 4, do so now. Note the location of the spacer shim(s), if equipped. Remove the heat shield used on both V8 models.

> ***Note:*** *On 5.7 litre V8 engines it is necessary to remove the steering rack pinch bolt and nut to give the starter enough room to clear the steering shaft.*

7 Refitting is the reverse of removal. Be sure to refit the spacer shim(s) in exactly the same location, if equipped. Renew the exhaust pipe-to-catalytic converter gasket if it was damaged.



17.5 There may be one or more shims used to correctly position the starter - don't lose them



19.3 Typical starter motor - exploded view

18 Starter solenoid - removal and refitting

Note: *It is recommended that the starter/solenoid assembly be exchanged as a complete unit in the event of failure.*

1 Remove the starter (refer to Section 16).
2 Disconnect the field coil wire from the solenoid.
3 Remove the mounting screws. There may be two or three.
4 Remove the solenoid and unhook the plunger from the starter as you do so.
5 There may be shims used in the solenoid assembly. Keep these for refitting later.
6 The remainder of refitting is the reverse of removal.

19 Starter motor overhaul

Refer to illustration 19.3

1 Remove the starter (see Section 17).
2 Remove the starter solenoid (see Section 18).
3 Draw alignment marks on the housing with white paint or a marking pen and unscrew the two through-bolts (see illustration).
4 Remove the commutator end housing, taking care to keep the sealing rubber seated in the housing.
5 Remove the dust cover and end cover, the horseshoe clip and any adjustment washers from the commutator end of the armature.
6 Hold the field coil cable seal in place and detach the commutator end cover.
7 Bend back the brush holder spring tabs, detach the springs and positive brushes, then remove the brush holder.
8 Remove the armature and the thrust washer from the housing.
9 Noting it's position, remove the sealing rubber from the drive end housing, then spread the fork lever arms and detach them from the pivots.
10 Place the planetary driveshaft in a padded vice and use two screwdrivers to prise the stop ring retainer in the direction of the drive assembly. Remove the driveshaft assembly from the vice. Use circlip pliers to remove the stop ring from the driveshaft.
11 Make sure the planetary driveshaft is free of burrs and slide the stop ring retainer and drive assembly off the driveshaft.
12 Prise off the cover plate from the ring gear and remove the planetary driveshaft ring gear retaining clip and washer.
13 Push the driveshaft out of the ring gear assembly.
14 After the starter motor has been completely disassembled, clean all parts with electrical contact cleaner. Do not use degreasing solvents; they can damage the electrical parts. Look for cracks in the case, burned spots and parts exhibiting signs of wear or other damage. Renew parts as necessary.
15 Clean the overrunning clutch with a clean cloth. If the commutator is dirty, clean it with 1200 sand paper. Never use emery cloth to clean a commutator.
16 Test the operation of the overrunning clutch. The pinion should turn freely in the overrunning direction only. Check the pinion teeth for chips, cracks and excessive wear. Renew the clutch assembly if damage or wear is evident. Badly chipped pinion teeth may indicate chipped teeth on the flywheel ring gear. If this is the case, be sure to check the ring gear and, if necessary, renew it.
17 Inspect the brushes for wear. Measure the length of the brushes and compare this measurement to the one listed at the beginning of this Chapter. Renew them as a set if any are worn. The brush holders must hold the brushes against the commutator. Make sure they're not bent or deformed.

18 To renew positive brushes, cut the lead about 4 mm from the connecting strap. Use needle-nose pliers to hold the new brush in place and solder it to the cut off lead. The lead needs to be flexible to allow normal brush movement, so make sure no solder migrates into the lead during attachment.

19 To renew the negative brushes, first note the direction in which they are soldered to the plate. Cut off the old brush lead at the lowest point of the braided section. Remove any remaining solder from the connection and then apply a 'tin' coat of solder to it. Use needle-nose pliers to hold the new brush in position, making sure it faces in the same direction as the original, then solder it in place.

20 Check the fit of the armature shaft in the bushes at each end of the motor housing. The shaft should fit snugly in the bushes. If the bushes are worn, renew them or obtain a rebuilt starter motor.

21 Check the commutator for wear. If it's heavily worn, out-of-round or the insulation strips between each segment are high, the armature should be turned on a lathe and the insulation strips should be undercut. This operation is best performed by a properly equipped automotive machine shop that's familiar with the procedure. It may be quicker and easier to obtain a rebuilt starter.

22 Using an ohmmeter or a continuity tester, check for shorts between each commutator segment and the armature. Renew the armature if there are any shorts.

23 Using an ohmmeter or a continuity tester, check for continuity between each commutator segment and the segment to its immediate right and left. There should be continuity. If there's no continuity, there's an open in the winding. The most likely places for opens to occur are at the points where the armature conductors join the commutator segments. Inspect these points for loose connections. Poor connections cause arcing and burning of the commutator segments as the starter motor is used. If the segments aren't too badly burned, the damage can often be repaired by resoldering the conductors to the segments and cleaning up the burned material on the commutator with 400 sandpaper.

24 Shorts are sometimes produced by carbon or copper dust (from the brushes) between the segments. They can usually be eliminated by cleaning out the slots between the segments. If a short persists, you'll need to take the armature to a properly equipped shop to be tested on a growler. Often, it's easier to simply obtain a rebuilt starter.

25 Check the armature and commutator for grounds. These often occur as a result of insulation failure brought about by overheating the starter motor by operating it for extended periods. They can also be caused by an accumulation of brush dust between the commutator segments and the steel commutator ring. Grounds in the armature and commutator can be detected with an ohmmeter or a continuity checker. Touch one probe of the test instrument to the armature shaft and touch the other probe to each of the commutator segments. If the instrument indicates continuity at any of the segments, the armature is earthed. If cleaning won't correct the earth problem, renew the armature (often it's easier to simply obtain a rebuilt starter).

26 Using an ohmmeter or a continuity tester, place one probe on each field coil connector. The instrument should indicate continuity. If there's not continuity, there's an open in one of the field coils. It's best to obtain a rebuilt starter, since field coil renewal normally requires special tools.

27 Place one probe of an ohmmeter or continuity tester on one of the field coil connectors. Place the other probe on the starter frame. Disconnect the shunt coil earth, if applicable, before you do this check. If the instrument indicates continuity, the field coils are earthed; obtain a rebuilt starter.

28 Reassembly is the reverse of removal.

Notes

Chapter 6
Emissions and engine control systems

Contents

Specifications

Coolant temperature resistance
- 3.8 litre V6 models
  - At 20 degrees C ..... 3,555 ohms
  - At 100 degrees C ..... 180 ohms
- 3.6 litre V6 models
  - At 20 degrees C ..... 2,450 ohms
  - At 100 degrees C .....

186 ohms
- 5.0 litre V8 models
  - At 20 degrees C ..... 2,500 ohms
  - At 100 degrees C ..... 190 ohms
- 5.7 litre Gen III and 6.0 litre Gen IV V8
  - At 20 degrees C ..... 3,520 ohms
  - At 100 degrees C ..... 177 ohms

Inlet air temperature sensor resistance
- 3.8 litre V6 and 5.0 litre V8 models
  - At 20 degrees C ..... 3,500 ohms
  - At 70 degrees C ..... 450 ohms
  - At 100 degrees C ..... 185 ohms
- 3.6 litre V6 models
  - At 20 degrees C ..... 2,290 to 2,551 ohms
  - At 60 degrees C ..... 565 to 654 ohms
  - At 100 degrees C ..... 184 to 222 ohms
- 5.7 litre Gen III V8 and 6.0 litre Gen IV V8
  - At 20 degrees C ..... 3,515 ohms
  - At 60 degrees C ..... 667 ohms
  - At 100 degrees C ..... 176 ohms

Torque specifications	Nm
Crankshaft sensor bolts	
3.8 litre V6 models	20 to 30
3.6 litre V6 models	8 to 12
5.7 litre Gen III and 6.0 litre Gen IV V8	25
Camshaft sensor bolt	
3.8 litre V6 models	11
3.6 litre V6 models	8 to 12
5.7 litre Gen III and 6.0 litre Gen IV V8	25

1 General information

Refer to illustration 1.5

To prevent pollution of the atmosphere from burned and evaporating gases, a number of emissions control systems are incorporated on the vehicles covered by this manual. The combination of systems used depends on the year in which the vehicle was manufactured, the locality to which it was originally delivered and the engine type. The major systems incorporated on the vehicles with which this manual is concerned include the:

Evaporative Emissions Control (EECS) system
Transmission Converter Clutch (TCC) system
Exhaust Gas Recirculation (EGR) system (V6 non-supercharged only)
Positive Crankcase Ventilation (PCV) system
Catalytic converter

All of these systems are linked, directly or indirectly, to the On Board Diagnostic (OBD) system. The Sections in this Chapter include general descriptions, checking procedures (where possible) and component renewal procedures (where applicable) for each of the systems listed above.

Before assuming that an emissions control system is malfunctioning, check the fuel and ignition systems carefully. In some cases special tools and equipment, as well as specialised training, are required to accurately diagnose the causes of a rough running or difficult to start engine. If checking and servicing become too difficult, or if a procedure is beyond the scope of the home mechanic, consult your dealer service department. This does not necessarily mean, however, that the emissions control systems are particularly difficult to maintain and repair. You can quickly and easily perform many checks and do most (if not all) of the regular maintenance at home with common tune-up and hand tools.

Note: *The most frequent cause of emissions system problems is simply a loose or broken vacuum hose or wiring connection. Therefore, always check the hose and wiring connections first.*

Pay close attention to any special precautions outlined in this Chapter. It should be noted that the illustrations of the various systems may not exactly match the system fitted on your particular vehicle due to changes made by the manufacturer during production or from year to year.

A Vehicle Emissions Control Information (VECI) label is located in the engine compartment of all vehicles with which this manual is concerned (see illustration). This label contains important emissions specifications and setting procedures, as well as a vacuum hose schematic with emissions components identified. When servicing the engine or emissions systems, the VECI label in your particular vehicle should always be checked for up-to-date information.

Note: *Because of an extended warranty which covers the emission control system components (and any components which have a primary purpose other than emission control but have significant effects on emissions), check with your dealer about warranty coverage before working on any emission related systems.*

Because of their more precise fuel/air management, fuel-injected engines use simpler emissions systems.

The number of emissions control system components on later model fuel-injected vehicles has actually decreased due to the high efficiency of the fuel injection and ignition systems. No longer needed are the dual bed catalytic converter (although a single bed or monolithic converter is still used) and many of the confusing thermal vacuum switches, valves and hoses.

1.5 A Vehicle Emissions Control Information (VECI) label will be found in the engine compartment of all vehicles - if it's missing, obtain a new one from a dealer parts department

2 On Board Diagnostic (OBD) system and trouble codes

Refer to illustrations 2.1 and 2.2

When the PCM detects a fault, the self diagnosis codes (fault codes) are recorded in the PCM memory and depending on the fault, will cause the Check Engine warning lamp to illuminate.

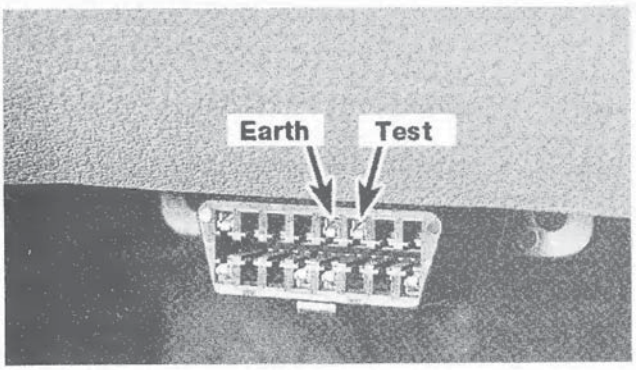
If the fault is intermittent, the warning lamp will extinguish after 10 seconds, however the code will be stored in memory until the memory is erased.

VT SERIES 1 MODELS

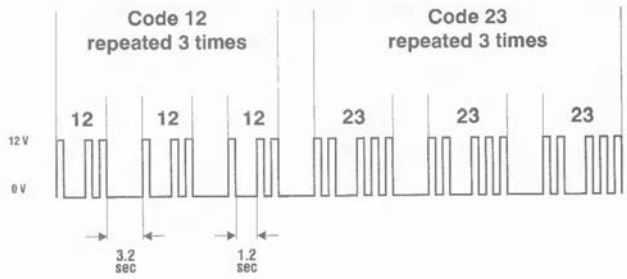
RETRIEVING FAULT CODES

VT Series I models utilise a flash code system. This system allows fault codes to be displayed as a series of flashes of the Check Engine lamp, once the data link connector Test and Earth terminals are bridged using a suitable piece of wire. With the ignition On, read the codes as follows:

1. Each code is represented by two groups of flashes separated by a 1.2 second pause.
2. The first group of flashes represents tens, the second group represents units. For example, three flashes, followed 1.2 seconds later by five flashes, would indicate code 35.
3. Each code will be displayed three times.
4. If more than one fault code is in memory, each code will be separated by a 3.2 second pause.
5. The sequence will be repeated as long as the diagnosis connector terminals are bridged.
6. Code 12 should be displayed three times at the start of the procedure to indicate that the self diagnosis system is operating.



2.1 The data link connector is below the steering wheel



2.2 Table showing how the flash codes are displayed

7 If there are fault codes in memory, code 12 will also be displayed at the completion of the code display.

8 If there are no fault codes in memory, code 12 will be continually displayed.

CONFIRMING CODES

The code/s should be confirmed prior to further diagnosis.

9 To confirm the codes, remove the bridge wire from the diagnosis connector terminals and clear the codes (see below).

10 Road test the vehicle and recheck the codes.

11 If the code is not set, an intermittent fault is indicated.

CLEARING CODES

12 With the bridging wire removed and the ignition Off, disconnect both battery terminals for at least 10 seconds.

13 Reconnect the battery.

ALL OTHER MODELS

RETRIEVING FAULT CODES

Models from VT Series 2 to VZ do not have flash codes but have a five digit OBD-II type fault codes. These codes begin with P for Powertrain; B for Body or U for Communication circuit fault codes. To obtain these codes, a scan tool is required.

14 The PCM will illuminate the CHECK ENGINE light (also called the Malfunction Indicator Light) on the dash if it recognises a component fault for two consecutive drive cycles. It will continue to set the light until the PCM does not detect any malfunction for three or more consecutive drive cycles.

15 The diagnostic codes for the OBD-II system can be extracted from the PCM by plugging a generic OBD-II scan tool into the PCM's data link connector, which is located under the dash.

Note: *An aftermarket generic scanner should work with any model covered by this manual. However, some early OBD-II models, although technically classified as OBD-II compliant by the manufacturer and by the federal government, might not be fully compliant with all SAE standards for OBD-II. Some generic scanners are unable to extract all "P0" codes from these early OBD-II models. Before purchasing a generic scan tool, contact the manufacturer of the scanner you're planning to buy and verify that it will work properly with the OBD-II system you want to scan. If necessary, of course, you can always have the codes extracted by a dealer service department or an independent repair shop with a professional scan tool that's capable of extracting the codes on all Holden models.*

16 Plug the scan tool into the 16-pin data link connector (DLC), and then turn the ignition key ON (engine not running) and make sure the CHECK ENGINE light on the instrument panel is on. If the light is off, either the bulb is burned out or there is a problem with the PCM or related circuit. Using the instructions included with the scan tool, extract any code(s) stored in the PCM.

CLEARING CODES

17 After you have extracted the diagnostic trouble codes and made any necessary repairs, make *sure that you "clear"* (erase) them before operating the vehicle. Also, always clear any stored codes from the PCM before replacing any electronic emission control component (information sensor or output actuator) that is part of the engine management system, i.e. computer controlled. Because the PCM stores trouble codes during sensor malfunctions, it will also store a code if a new sensor is installed before any codes regarding the old sensor have been erased. Clearing the old codes allows the computer to relearn the new operating parameters relayed by the new component. During the computer relearning process, the engine may experience a rough idle or slight driveability changes. This period of time, however, should last no longer than 15 to 20 minutes.

18 Plug the scan tool into the 16-pin DLC, scroll the menu for the "CLEARING CODES" mode and follow the manufacturer's instructions.

Caution 1: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

Caution 2: *To prevent damage to the PCM, the ignition switch must be off when disconnecting or connecting power to the PCM.*

Note: *Component renewal may not cure the problem in all cases. For this reason, you may want to seek professional advice before purchasing renewal parts.*

VT SERIES 1 V6 AND 5.0 LITRE V8 ENGINES

Trouble code	Circuit or system
12	Normal operation
13	Oxygen sensor or circuit problem
14	Coolant temp sensor or circuit problem
15	Coolant temp sensor or circuit problem
16	Coolant temp sensor or circuit problem
17	PCM coolant temp circuit problem
18	EGR system flow problem, V6 non-supercharged
19	Throttle position sensor or circuit problem
21	Throttle position sensor or circuit problem
22	Throttle position sensor or circuit problem
23	Inlet air temp sensor or circuit problem
24	Vehicle speed sensor or circuit problem
25	Inlet air temp sensor or circuit problem
26	Inlet air temp sensor or circuit problem
28	Transmission problem, consult a specialist
29	EGR position problem, V6 non-supercharged
31	Theft deterrent system problem
32	Mass air flow sensor or circuit problem
33	Manifold absolute pressure sensor or circuit problem
34	Manifold absolute pressure sensor or circuit problem
35	Idle speed error
36	Vacuum leak
41	Electronic spark timing problem
42	Ignition bypass circuit problem
43	Knock sensor or circuit problem
44	Lean exhaust
45	Rich exhaust
46	No reference signal from ignition module while cranking
47	No 18X reference signal from ignition module
48	Camshaft position signal missing
49	Cam/crank signal intermittent
51	PCM PROM problem
52	System voltage problem
53	System voltage problem
54	System voltage unstable
55	PCM problem
56	Runs lean under load
57	Injector voltage monitor circuit fault
58	Transmission problem, consult a specialist
59	Transmission problem, consult a specialist
63	Oxygen sensor or circuit problem
64	Lean exhaust
65	Rich exhaust
66	Transmission problem, consult a specialist
67	Transmission problem, consult a specialist
68	Transmission slipping, consult a specialist
69	Transmission problem, consult a specialist
72	Vehicle speed sensor or circuit problem

Trouble code	Circuit or system
73	Transmission problem, consult a specialist
75	System voltage problem
76	Short term fuel trim problem
78	Long term fuel trim problem
79	Transmission problem, temperature too high
81	Transmission problem, consult a specialist
82	Transmission problem, consult a specialist
83	Transmission problem, consult a specialist

Trouble code	Circuit or system
85	Transmission slipping, consult a specialist
91	PCM problem
92	Low speed fan problem
93	PCM problem
94	No vehicle speed signal
95	PCM/Traction Control system problem
96	Air conditioning pressure sensor problem
97	Canister purge system problem

ALL MODELS

Trouble code	Circuit or system
B0980	Power/Economy switch signal error
B1000	PIM RAM test error
B1009	EEPROM checksum error
B1013	ROM checksum error
B1014	Program ROM checksum error
B1019	PIM configuration error
B273A	Hill descent switch signal error
B2745	Traction control ESP switch signal error
B3294	BCM security code signal error

Trouble code	Circuit or system
P0008	Engine Position System Performance - Bank 1
P0009	Engine Position System Performance - Bank 2
P0010	Intake variable cam timing solenoid circuit open - Bank 1
P0011	Intake variable cam timing solenoid over-advanced - Bank 1
P0013	Exhaust variable cam timing solenoid circuit open - Bank 1
P0014	Exhaust variable cam timing solenoid over-advanced - Bank 1
P0016	Valve timing out of sequence - Bank 1, Sensor 1

ALL MODELS (CONTINUED)

Trouble code	Circuit or system
P0017	Valve timing out of sequence - Bank 1, Sensor 2
P0018	Valve timing out of sequence - Bank 2, Sensor 1
P0019	Valve timing out of sequence - Bank 2, Sensor 2
P0020	Intake variable cam timing solenoid circuit open - Bank 2
P0021	Intake variable cam timing solenoid over-advanced - Bank 2
P0023	Exhaust variable cam timing solenoid circuit open - Bank 2
P0024	Exhaust variable cam timing solenoid over-advanced - Bank 2
P0030	Oxygen sensor heater circuit malfunction - Bank 1, Sensor 1
P0031	Oxygen sensor heater circuit low - Bank 1, Sensor 1
P0032	Oxygen sensor heater circuit high - Bank 1, Sensor 1
P0036	Oxygen sensor heater circuit malfunction - Bank 1, Sensor 2
P0037	Oxygen sensor heater circuit low - Bank 1, Sensor 2
P0038	Oxygen sensor heater circuit high - Bank 1, Sensor 2
P0040	Oxygen sensor signals swapped between banks - Sensor 1
P0041	Oxygen sensor signals swapped between banks - Sensor 2
P0050	Oxygen sensor heater circuit malfunction - Bank 2, Sensor 1
P0051	Oxygen sensor heater circuit low - Bank 2, Sensor 1
P0052	Oxygen sensor heater circuit high - Bank 2, Sensor 1
P0053	Oxygen sensor heater resistance - Bank 1, Sensor 1
P0056	Oxygen sensor heater circuit malfunction - Bank 2, Sensor 2
P0057	Oxygen sensor heater circuit low - Bank 2, Sensor 2
P0058	Oxygen sensor heater circuit high - Bank 2, Sensor 2
P0059	Oxygen sensor heater resistance - Bank 2, Sensor 1
P0101	Air flow sensor volume signal error
P0102	Air flow sensor volume signal low
P0103	Air flow sensor volume signal high
P0112	Intake air temperature sensor signal voltage low
P0113	Intake air temperature sensor signal voltage high
P0115	Coolant temperature sensor signal out of range
P0116	Coolant temperature sensor signal error
P0117	Coolant temperature sensor signal low
P0118	Coolant temperature sensor signal high
P0120	TPS signal error
P0121	TPS signal out of range - Sensor 1
P0122	TPS signal low - Sensor 1
P0123	TPS signal - high - Sensor 1
P0125	Coolant temperatur signal out of range
P0130	Oxygen sensor signal out of range - Bank 1, Sensor 1
P0131	Oxygen sensor signal low - Bank 1, Sensor 1
P0132	Oxygen sensor signal high - Bank 1, Sensor 1
P0133	Oxygen sensor signal slow to respond - Bank 1, Sensor 1
P0135	Oxygen sensor heater circuit malfunction - Bank 1, Sensor 1
P0137	Oxygen sensor signal low - Bank 1, Sensor 2
P0138	Oxygen sensor signal high - Bank 1, Sensor 2
P0139	Oxygen sensor signal slow to respond - Bank 1, Sensor 2

Trouble code	Circuit or system
P0140	Oxygen sensor signal missing - Bank 1, Sensor 2
P0141	Oxygen sensor heater circuit malfunction - Bank 1, Sensor 2
P0150 Sensor 1	Oxygen sensor signal out of range - Bank 2,
P0151	Oxygen sensor signal low - Bank 2, Sensor 1
P0152	Oxygen sensor signal high - Bank 2, Sensor 1
P0153	Oxygen sensor signal slow to respond - Bank 2, Sensor 1
P0155	Oxygen sensor heater circuit malfunction - Bank 2, Sensor 1
P0157	Oxygen sensor signal low - Bank 2, Sensor 2
P0158	Oxygen sensor signal high - Bank 2, Sensor 2
P0160	Oxygen sensor signal missing - Bank 2, Sensor 2
P0161	Oxygen sensor heater circuit malfunction - Bank 2, Sensor 2
P0196	Engine oil temperature sensor signal out of range
P0197	Engine oil temperature sensor signal voltage low
P0198	Engine oil temperature sensor signal voltage high
P0201	No 1 cylinder injector fault
P0202	No 2 cylinder injector fault
P0203	No 3 cylinder injector fault
P0204	No 4 cylinder injector fault
P0205	No 5 cylinder injector fault
P0206	No 6 cylinder injector fault
P0218	Transmission fluid temperature high
P0219	Engine over speed condition
P0221	TPS signal out of range - Sensor 2

Trouble code	Circuit or system
P0222	TPS signal low - Sensor 2
P0223	TPS signal high - Sensor 2
P0261	No 1 cylinder injector circuit voltage low
P0262	No 1 cylinder injector circuit voltage high
P0264	No 2 cylinder injector circuit voltage low
P0265	No 2 cylinder injector circuit voltage high
P0267	No 3 cylinder injector circuit voltage low
P0268	No 3 cylinder injector circuit voltage high
P0270	No 4 cylinder injector circuit voltage low
P0271	No 4 cylinder injector circuit voltage high
P0273	No 5 cylinder injector circuit voltage low
P0274	No 5 cylinder injector circuit voltage high
P0276	No 6 cylinder injector circuit voltage low
P0277	No 6 cylinder injector circuit voltage high
P0300	Random multiple cylinder misfire detected
P0301	No 1 cylinder misfire detected
P0302	No 2 cylinder misfire detected
P0303	No 3 cylinder misfire detected
P0304	No 4 cylinder misfire detected
P0305	No 5 cylinder misfire detected
P0306	No 6 cylinder misfire detected
P0324	Knock sensor module performance malfunction
P0327	Knock sensor signal low - Bank 1
P0328	Knock sensor signal high - Bank 1
P0332	Knock sensor signal low - Bank 2

ALL MODELS (CONTINUED)

Trouble code	Circuit or system
P0333	Knock sensor signal high - Bank 2
P0335	Crankshaft position sensor signal error
P0336	Crankshaft position sensor reference signal error
P0337	Crankshaft position sensor reference signal error
P0338	Crankshaft position sensor reference signal error
P0341	Intake camshaft position sensor signal out of range - Bank 1
P0342	Intake camshaft position sensor signal low - Bank 1
P0343	Intake camshaft position sensor signal high - Bank 1
P0346	Intake camshaft position sensor signal out of range - Bank 2
P0347	Intake camshaft position sensor signal low - Bank 2
P0348	Intake camshaft position sensor signal high - Bank 2
P0351	No 1 ignition coil control circuit open
P0352	No 2 ignition coil control circuit open
P0353	No 3 ignition coil control circuit open
P0354	No 4 ignition coil control circuit open
P0355	No 5 ignition coil control circuit open
P0356	No 6 ignition coil control circuit open
P0366	Intake camshaft position sensor signal low - Bank 1
P0367	Exhaust camshaft position sensor signal high - Bank 1
P0368	Exhaust camshaft position sensor signal intermittent - Bank 1
P0391	Exhaust camshaft position sensor signal out of range - Bank 2
P0392	Exhaust camshaft position sensor signal low - Bank 2
P0393	Exhaust camshaft position sensor signal high - Bank 2

Trouble code	Circuit or system
P0420	Catalyst operating efficiency below threshold - Bank 1
P0430	Catalyst operating efficiency below threshold - Bank 2
P0443	Canister purge solenoid circuit fault
P0458	Canister purge solenoid circuit low
P0459	Canister purge solenoid circuit high
P0460	Fuel level sensor signal error
P0461	Fuel level sensor signal out of range
P0462	Fuel level sensor signal low
P0463	Fuel level sensor signal high
P0480	No 1 fan relay driver circuit fault
P0481	No 2 fan relay driver circuit fault
P0500	Vehicle speed sensor signal missing - M/T models
P0504	Stop lamp switch circuit mismatch - Sensor A - Sensor C
P0506	Idle speed low
P0507	Idle speed high
P0513	Incorrect immobiliser key
P0521	Engine oil pressure sensor signal out of range
P0522	Engine oil pressure sensor signal low
P0523	Engine oil pressure sensor signal high
P0532	A/C pressure signal low
P0533	A/C pressure signal high
P0560	ECM power supply error
P0562	System power supply voltage low
P0563	System power supply voltage high

Trouble code	Circuit or system
P0565	Cruise control On switch signal error
P0567	Cruise control Resume switch signal error
P0568	Cruise control Set switch signal error
P0572	Stop lamp switch signal voltage high
P0573	Stop lamp switch signal voltage low
P0601	ECM ROM error
P0601	TCM ROM error
P0602	VID programming error
P0602	VID programming error
P0603	TCM keep alive memory error
P0604	Internal ECM error RAM access
P0604	Internal TCM error RAM access
P0606	Internal ECM processor error
P0615	Starter relay circuit malfunction
P0616	Starter relay circuit low
P0617	Starter relay circuit high
P0625	Alternator field coil circuit low
P0626	Alternator field coil circuit high
P0627	Fuel pump relay driver circuit malfunction
P0628	Fuel pump relay driver circuit low
P0629	Fuel pump relay driver circuit high
P0633	Immobiliser security code or key not programmed
P0638	Throttle valve position error - Bank 1
P0645	A/C compressor relay control circuit malfunction
P0646	A/C compressor relay control circuit low

Trouble code	Circuit or system
P0647	A/C compressor relay control circuit high
P0685	Engine control relay open circuit
P0686	Engine control relay circuit low
P0687	Engine control relay circuit high
P0691	No 1 cooling fan circuit low
P0692	No 1 cooling fan circuit high
P0693	No 2 cooling fan circuit low
P0694	No 2 cooling fan circuit high
P0700	TCM requests Check Engine lamp illumination
P0704	Clutch switch signal error
P0711	TFT sensor signal out of range
P0712	TFT sensor signal voltage low
P0713	TFT sensor signal voltage high
P0716	Input shaft speed signal out of range
P0717	Input shaft speed signal low or missing
P0719	Stop lamp switch signal voltage high
P0722	Vehicle/output shaft speed signal missing
P0723	Vehicle speed signal intermittent
P0724	Stop lamp switch signal low
P0727	Engine speed signal to TCM missing
P0741	Torque converter clutch solenoid stuck Off
P0742	Torque converter clutch solenoid stuck On
P0748	Pressure control solenoid circuit malfunction
P0751	1-2 shift solenoid malfunction
P0752	1-2 shift solenoid malfunction

ALL MODELS (CONTINUED)

Trouble code	Circuit or system
P0756	2-3 shift solenoid malfunction
P0757	2-3 shift solenoid malfunction
P0761	4-5 shift solenoid malfunction
P0762	4-5 shift solenoid malfunction
P0787	3-2 shift solenoid circuit low
P0788	3-2 shift solenoid circuit high
P0815	Upshift switch circuit malfunction
P0816	Downshift switch circuit malfunction
P0826	Active select switch signal error
P0850	Park/Neutral switch input signal error
P0864	TCM communication circuit error
P0894	Transmission components slipping
P0961	Pressure control solenoid circuit out of range
P0973	1-2 shift solenoid circuit open or shorted to earth
P0974	1-2 shift solenoid circuit shorted to power
P0976	2-3 shift solenoid circuit open or shorted to earth
P0977	2-3 shift solenoid circuit shorted to power
P0979	4-5 shift solenoid circuit open or shorted to earth
P0980	4-5 shift solenoid circuit shorted to power
P1011	Intake variable cam timing solenoid unlocked - Bank 1
P1012	Exhaust variable cam timing solenoid unlocked - Bank 1
P1013	Intake variable cam timing solenoid unlocked - Bank 2
P1014	Exhaust variable cam timing solenoid unlocked - Bank 2
P1258	Engine in overheat mode

Trouble code	Circuit or system
P1551	Closed throttle valve position out of range
P1611	Incorrect PIM security code entered
P1621	TCM long term memory malfunction
P1629	Immobiliser system malfunction
P1632	Incorrect immobiliser key
P1648	ECM programming malfunction
P1668	Alternator L circuit malfunction
P1677	Immobiliser system malfunction
P1678	ECM security code signal error
P1679	Immobiliser system malfunction
P1793	Wheel speed signal error
P1810	TFP manual valve position switch circuit malfunction
P1815	TFP manual valve position switch signal error or A/T mode switch signal error
P1816	TFP manual valve position switch signal error
P1820	IMS circuit A signal error
P1822	IMS circuit B signal error
P1823	IMS circuit P signal error
P1825	IMS switch signal out of range
P1826	IMS circuit C signal error
P1831	TCM high side driver 1 circuit shorted to earth
P1832	TCM high side driver 1 circuit shorted to power
P1833	TCM high side driver 2 circuit shorted to earth
P1834	TCM high side driver 2 circuit shorted to power
P1845	Engine torque reduction error
P2008	Variable intake manifold control circuit malfunction

Trouble code	Circuit or system
P2009	Variable intake manifold control solenoid circuit low
P2010	Variable intake manifold control solenoid circuit high
P2088	Intake variable cam timing solenoid circuit low - Bank 1
P2089	Intake variable cam timing solenoid circuit high - Bank 1
P2090	Exhaust variable cam timing solenoid circuit low - Bank 1
P2091	Exhaust variable cam timing solenoid circuit high - Bank 1
P2092	Intake variable cam timing solenoid circuit low - Bank 2
P2093	Intake variable cam timing solenoid circuit high - Bank 2
P2094	Exhaust variable cam timing solenoid circuit low - Bank 2
P2095	Exhaust variable cam timing solenoid circuit high - Bank 2
P2096	Post catalyst fuel trim too lean - Bank 1
P2097	Post catalyst fuel trim too rich - Bank 1
P2098	Post catalyst fuel trim too lean - Bank 2
P2099	Post catalyst fuel trim too rich - Bank 2
P2100	Throttle control motor driver malfunction
P2101	Throttle control motor circuit malfunction - Circuit 1 or A
P2105	Electronically controlled throttle motor error
P2107	Electronically controlled throttle motor module processor malfunction
P2119	Throttle control motor slow movement
P2122	Throttle pedal position sensor signal low - Sensor 1
P2123	Throttle pedal position sensor signal high - Sensor 1

Trouble code	Circuit or system
P2127	Throttle pedal position sensor signal low - Sensor 1
P2128	Throttle pedal position sensor signal high - Sensor 1
P2138	Throttle pedal position sensor - difference between sensor 1 - 2 signals excessive
P2176	Electronically controlled throttle system self learn incomplete
P2177	System too lean - Bank 1
P2178	System too rich - Bank 1
P2179	System too lean - Bank 2
P2180	System too rich - Bank 2
P2187	System too lean - Bank 1
P2188	System too rich - Bank 1
P2189	System too lean - Bank 2
P2190	System too rich - Bank 2
P2195	Oxygen sensor signal stuck lean - Bank 1, Sensor 1
P2196	Oxygen sensor signal stuck rich - Bank 1, Sensor 1
P2197	Oxygen sensor signal stuck lean - Bank 2, Sensor 1
P2198	Oxygen sensor signal stuck rich - Bank 2, Sensor 1
P2227	Barometric pressure sensor signal out of range
P2228	Barometric pressure sensor signal low
P2229	Barometric pressure sensor signal high
P2231	Oxygen sensor signal circuit shorted to heater circuit - Bank 1, Sensor 1
P2232	Oxygen sensor signal circuit shorted to heater circuit - Bank 1, Sensor 2
P2234	Oxygen sensor signal circuit shorted to heater circuit - Bank 2, Sensor 1
P2235	Oxygen sensor signal circuit shorted to heater circuit - Bank 2, Sensor 2

ALL MODELS (CONTINUED)

Trouble code	Circuit or system
P2237	Oxygen sensor pumping current circuit out of range - Bank 1, Sensor 1
P2238	Oxygen sensor pumping current circuit low - Bank 1, Sensor 1
P2239	Oxygen sensor pumping current circuit pumping current - Bank 1, Sensor 1
P2240	Oxygen sensor pumping current circuit open - Bank 1, Sensor 1
P2241	Oxygen sensor pumping current circuit low - Bank 2, Sensor 1
P2242	Oxygen sensor pumping current circuit pumping current - Bank 2, Sensor 1
P2243	Oxygen sensor signal voltage out of range - Bank 1, Sensor 1
P2247	Oxygen sensor signal voltage out of range - Bank 2, Sensor 1
P2251	Oxygen sensor low circuit open - Bank 1, Sensor 1
P2254	Oxygen sensor low circuit open - Bank 2, Sensor 1
P2270	Oxygen sensor signal stuck lean - Bank 1, Sensor 2
P2271	Oxygen sensor signal stuck rich - Bank 1, Sensor 2
P2272	Oxygen sensor signal stuck lean - Bank 2, Sensor 2
P2273	Oxygen sensor signal stuck rich - Bank 2, Sensor 2
P2297	Oxygen sensor signal out of range during deceleration - Bank 1, Sensor 1
P2298	Oxygen sensor signal out of range during deceleration - Bank 2, Sensor 1
P2300	No 1 ignition coil control circuit shorted
P2301	No 1 ignition coil control circuit shorted
P2303	No 2 ignition coil control circuit shorted
P2304	No 2 ignition coil control circuit shorted
P2306	No 3 ignition coil control circuit shorted
P2307	No 3 ignition coil control circuit shorted
P2309	No 4 ignition coil control circuit shorted
P2310	No 4 ignition coil control circuit shorted
P2312	No 5 ignition coil control circuit shorted
P2313	No 5 ignition coil control circuit shorted
P2315	No 6 ignition coil control circuit shorted
P2316	No 6 ignition coil control circuit shorted
P2500	Alternator L circuit voltage low
P2501	Alternator L circuit voltage high
P2626	Oxygen sensor pumping current trim circuit open - Bank 1, Sensor 1
P2627	Oxygen sensor pumping current trim circuit low - Bank 1, Sensor 1
P2628	Oxygen sensor pumping current trim circuit high - Bank 1, Sensor 1
P2629	Oxygen sensor pumping current trim circuit open - Bank 2, Sensor 1
P2630	Oxygen sensor pumping current trim circuit low - Bank 2, Sensor 1
P2631	Oxygen sensor pumping current trim circuit high - Bank 2, Sensor 1
P2637	Engine speed signal to TCM missing
P2763	TCC PWM solenoid circuit high
P2764	TCC PWM solenoid circuit low
P2769	TCC enable solenoid circuit low
P2770	TCC enable solenoid circuit high
U0001	High speed CAN communication Bus error
U0100	TCM communication Bus error
U0101	TCM communication missing
U0121	Lost communication with ABS control module

Trouble code	Circuit or system
U0155	Serial data communication error with PIM
U0415	Invalid data received from ABS control module
U0423	Serial data communication error with PIM
U1304	UART serial data missing
U2100	CAN Bus communication signal error
U2105	CAN Bus communication signal error
U2106	CAN Bus communication signal error
U2107	BCM communication malfunction
U2108	ABS/traction control module communication signal error

3 Powertrain Control Module (PCM) - check and renewal

PCM CHECK

1 On 3.8 litre V6 and 5.0 litre V8 models, remove the passenger side kick panel to gain access to the PCM. On Gen III and Gen IV models, the PCM is on the LH inner guard inside the engine compartment. On 3.6 litre V6 models, the ECM is located on the front of the RH cylinder head.

2 Using the tips of the fingers, tap vigorously on the side of the computer while the engine is running. If the computer is not functioning properly, the engine will stumble or stall and display glitches on the engine data stream obtained using a SCAN tool or other diagnostic equipment.

3 If the PCM fails this test, check the electrical connectors. Each connector is colour coded to fit the respective slot in the computer body. If their are no obvious signs of damage, have the unit checked at a dealer service department.

PCM RENEWAL

Caution: *To prevent damage to the PCM, the ignition switch must be turned Off when disconnecting or connecting in the PCM connectors.*

4 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

5 Remove the wiring connectors from the PCM.

6 Carefully pull back the retaining clips and lift the PCM from the bracket without damaging the electrical connectors and wiring harness to the computer.

7 Refitting is the reverse of removal. Make certain to transfer the codes and numbers from the old unit to the new. Future computer work will be very difficult without this information.

Note: *On 3.8 litre V6 and 5.0 litre V8 models, if you are refitting a renewal PCM, it is necessary to refit the PROM from the old PCM into the new unit.*

PROM RENEWAL

Refer to illustrations 3.9 and 3.10

Note: *This is only applicable to VT 3.8 litre V6, 3.8 litre supercharged V6 and 5.0 litre V8 models. All other models use an EEPROM, which is an integral part of the PCM.*

8 The PCM must be removed for this procedure.

3.9 Remove the two screws and the PROM access cover from the PCM

3.10 Using your thumb and finger, press the PROM carrier retainers in and pull the PROM straight up

9 Remove the two screws and the access cover from the PROM (see illustration).

10 Carefully pull out the PROM (see illustration).

> ***Caution:*** *The PROM and its terminals are very delicate. Take care to avoid bending or otherwise damaging the terminals when handling the PROM.*

11 Align and insert the new PROM. Push down on each end until the retainers are in position to be pressed into place.

12 Press the clips into the PROM until they snap.

13 The remainder of the refitting is the reverse of removal.

14 Check for trouble codes. There should only be code 12.

4 Information sensors - check and renewal

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

General description

Refer to illustration 4.1

1 The coolant temperature sensor is a thermistor (a resistor which varies the value of its resistance in accordance with temperature changes). As the sensor temperature DECREASES, the resistance will INCREASE. As the sensor temperature INCREASES, the resistance will DECREASE. A failure in the coolant sensor circuit should set a code. These codes indicate a failure in the coolant temperature circuit, so the appropriate solution to the problem will be either repair of a wire or renewal of the sensor.

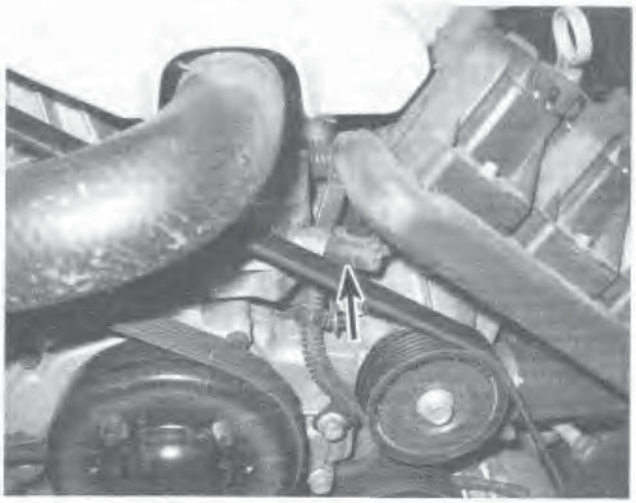
> ***Note:*** *The ECT sensor is located below the thermostat housing on both V6 and V8 models (see illustration). On all models except supercharged vehicles, the sensor is located at the front of the engine. It is at the rear on supercharged V6 models.*

Check

2 To check the sensor, check the resistance of the coolant temperature sensor while it is completely cold. Next, start the engine and warm it up until it reaches operating temperature. The resistance should be much lower. Compare your readings with those listed in the Specifications in this Chapter.

3 Check the reference voltage supplied to the sensor by the PCM with the ignition key ON (engine not running) and the wiring harness disconnected. It should be approximately 5.0 volts. Refer to the wiring diagrams at the end of Chapter 12 for the correct wire colours.

4 Access to the coolant temperature sensor is difficult, making it impossible to monitor the resistance changes without removing other components from the engine. Refit the SCAN tool and switch to the ECT mode and monitor the temperature of a cold engine. The SCAN tool should indicate between 24 to 32-degrees C. Allow the engine to idle for several minutes and observe the coolant temperature increase as the engine warms up. The temperature should indicate between 95 to 100-degrees C at normal operating temperature. If there is not a definite change in temperature, remove



4.1 The coolant temperature sensor is located below the thermostat housing

the coolant temperature sensor and check the resistance in a pan of heated water to simulate warm-up conditions. If the sensor tests are good, check the wiring harness from the sensor to the computer (see Chapter 12 wiring diagrams).

Renewal

Warning: *Wait until the engine is completely cool before beginning this procedure.*

5 Refer to Chapter 3 and follow the procedure for renewing the coolant temperature sensor.

6 To remove the sensor, release the locking tab, unplug the electrical connector, then carefully unscrew the sensor.

Caution: *Handle the coolant sensor with care. Damage to this sensor will affect the operation of the entire fuel injection system.*

7 Before fitting the new sensor, wrap the threads with Teflon sealing tape to prevent leakage and thread corrosion. Refitting is the reverse of removal.

INLET AIR TEMPERATURE (IAT) SENSOR

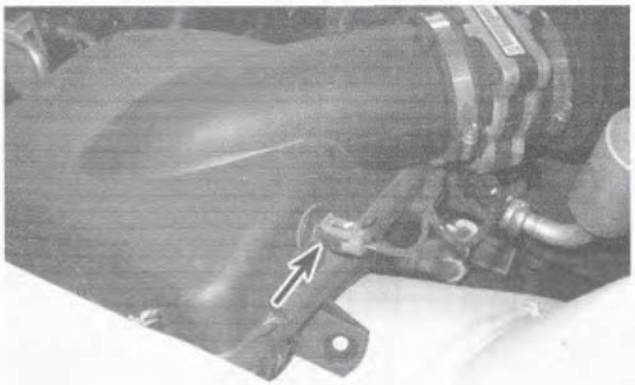
General description

Refer to illustration 4.8

8 The air temperature sensor is fitted into the air filter housing, on some models (see illustration). If it is not in the position illustrated, it is incorporated within the mass air flow sensor (MAF). This sensor acts as a thermistor (a resistor which changes the value of its resistance as the temperature changes). When the inlet air is cold, the sensor resistance is high, therefore the PCM will read a low signal voltage. If the inlet air is warm, the resistance is low giving the PCM a high voltage reading. The PCM supplies approximately 5.0 volts (reference voltage) to the IAT sensor. A failure in the IAT sensor circuit should set a code.

Check

9 Disconnect the IAT electrical sensor, or MAF sensor on VZ models, and with the ignition key ON (engine not running),



4.8 The inlet air temperature sensor (arrow) is secured to the air cleaner housing with a retainer on the inside. This retainer must be cut in order to remove the sensor

probe terminal 1 EARTH and terminal 2 REF. The voltmeter should read approximately 5.0 volts. Then measure the resistance across the two temperature sensor terminals (see illustration 4.19). By measuring its resistance when cold, then warming it up (a hair dryer can be used for this) and taking another measurement. The resistance of the IAT sensor should be HIGH when the temperature is low.

Note: *The connector insets in illustration 4.19 are viewed as if looking into the rear of the wiring connector while it is connected to the sensor.*

10 Next, start the engine and let it idle (reconnect the sensor connector first). Wait awhile and let the engine reach operating temperature. Turn the ignition key OFF, disconnect the sensor connector and check the resistance across the air temperature sensor terminals. The resistance should be LOW when the air temperature is high. If the sensor does not exhibit this change in resistance, renew the sensor. Compare your readings with those in the Specifications in this Chapter.

11 An alternate method of diagnosing the IAT sensor is by the use of an electronic SCAN tool. Refit the SCAN tool and switch to the IAT mode. Monitor the temperature with the engine cold and then completely warmed-up. The SCAN tool temperature ranges should increase while the IAT sensor resistance decreases. If the IAT sensor temperature/resistance readings are incorrect, renew the IAT sensor.

Renewal

12 Remove the upper air cleaner housing (refer to Chapter 1).

13 Disconnect the wiring harness from the sensor.

14 Using side-cutting pliers, cut the sheet metal retainer that secures the sensor to the air cleaner housing. Lift out the sensor.

15 Refitting is the reverse of removal. Use a large socket to push the new retainer onto the sensor.

MASS AIR FLOW (MAF) SENSOR

General description

16 The Mass Air Flow (MAF) sensor, which is located in a housing between the air cleaner housing and the throttle body in the inlet duct, measures the amount of air entering the engine. A large quantity of air entering the engine indicates an acceleration or high speed situation, while a small quantity of air indicates deceleration or idle. The PCM uses this information to control fuel delivery. The MAF sensor produces a frequency signal that will vary within a range of around 2,000 Hertz at idle to 10,000 Hertz at maximum load conditions. A failure in the MAF sensor circuit should set a code.

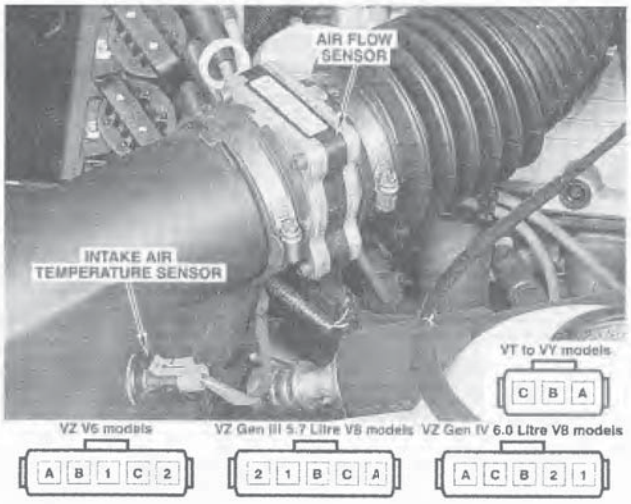
CHECK

Refer to illustration 4.19

17 A quick check of the sensor can be made by tapping the flat portion of the sensor body with a screwdriver handle as the engine is running. If the engine stumbles or stalls, the sensor is faulty. This test works only in an intermittent failure situation. If the engine does not start or fails to idle smoothly, continue the checks.

18 Check the inlet air duct for leaks. Check for a plugged exhaust system.

19 Check the SIGNAL voltage. Disconnect the MAF electrical connector and with the ignition key ON (engine not running),



4.19 Check the Mass Air Flow (MAF) sensor signal voltage on terminal A (+) and terminal B (-). It should be approximately 5.0 volts. Note that the illustration is drawn as if looking into the rear of the wiring connectors while connected to the sensor

check the voltage on terminal B EARTH and terminal A SIGNAL (see illustration). There should be between 4 to 6 volts. If the voltage is higher or lower, check the wiring harness for shorts or check for a faulty PCM.

20 Next, check for battery voltage to the MAF sensor. With the ignition key ON (engine not running), check the voltage on terminal B EARTH and terminal C. There should be approximately 12 volts. If all the checks are correct, and the OBD system indicates a MAF code, have the vehicle checked at a dealer service department.

21 An alternate method of diagnosing the MAF sensor is by the use of an electronic SCAN tool. Refit the SCAN tool and switch to the MAF mode and monitor the frequency signal with the engine at idle and high rpm. The SCAN tool should indicate HIGH or LOW. Raise the engine rpm and observe that as engine rpm increases the MAF signal also changes (increases). If the MAF sensor voltage readings are incorrect, renew the MAF sensor. Different SCAN tools will have different values for the MAF sensor data; some will simply read HIGH or LOW, while other will give frequency values in hertz.

Renewal

Refer to illustration 4.22

22 To renew the MAF sensor, unplug the electrical connector, loosen the clamps and detach the sensor from the air ducts (see illustration).

23 Refitting is the reverse of removal.

OXYGEN SENSOR

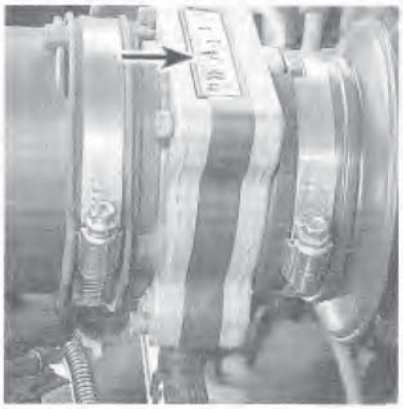
General description

Refer to illustration 4.24

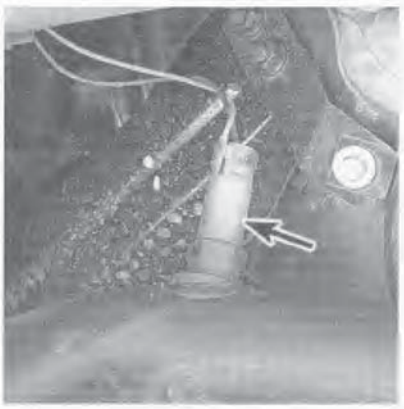
24 The oxygen sensor, which is located in the exhaust manifold or pipe, monitors the oxygen content of the exhaust gas stream (see illustration). The oxygen content in the exhaust reacts with the oxygen sensor to produce a voltage output which varies from 0.1-volt (high oxygen, lean mixture) to 0.9-volts (low oxygen, rich mixture). The PCM constantly monitors this variable voltage output to determine the ratio of oxygen to fuel in the mixture. The PCM alters the air/fuel mixture ratio by controlling the pulse width (open time) of the fuel injectors. A mixture ratio of 14.7 parts air to 1 part fuel is the ideal mixture ratio for normal driving, thus allowing the catalytic converter to operate at maximum efficiency. It is this ratio of 14.7 to 1 which the PCM and the oxygen sensor attempt to maintain while cruising.

> ***Note:*** *All models use one oxygen sensor in each exhaust pipe before the catalytic converter. Some VZ models also have another oxygen sensor after each catalytic converter. These sensors work in the same way as the ones before the catalytic converter. However, the job of the sensors after the catalytic converter is to inform the PCM if the catalytic converters are working correctly.*

25 The oxygen sensor produces no voltage when it is below its normal operating temperature of about 315-degrees C.



4.22 The MAF sensor is located in the air duct next to the air cleaner housing



4.24 All engines have an oxygen sensor (arrow) in each exhaust pipe

4.41 The throttle position sensor (arrow) is located directly on the throttle body on all engines. Do not lose the plastic drive adapter when the throttle body has been removed

During this initial period before warm-up, the PCM operates in OPEN LOOP mode. Some models have oxygen sensors which have a heating element inside to heat the sensor and get the vehicle operating in CLOSED LOOP quicker.

26 If the engine reaches normal operating temperature and/or has been running for two or more minutes, and if the computer detects a malfunction, the PCM will set a code.

27 When there is a problem with the oxygen sensor or its circuit, the PCM operates in the open loop mode - that is, it controls fuel delivery in accordance with a programmed default value instead of feedback information from the oxygen sensor.

28 The proper operation of the oxygen sensor depends on four conditions:

*a) **Electrical** - The low voltages generated by the sensor depend upon good, clean connections which should be checked whenever a malfunction of the sensor is suspected or indicated.*

*b) **Outside air supply** - The sensor is designed to allow air circulation to the internal portion of the sensor. Whenever the sensor is removed and refitted or renewed, make sure the air passages are not restricted.*

*c) **Proper operating temperature** - The PCM will not react to the sensor signal until the sensor reaches approximately 350-degrees C. This factor must be taken into consideration when evaluating the performance of the sensor.*

*d) **Unleaded fuel** - The use of unleaded fuel is essential for proper operation of the sensor. Make sure the fuel you are using is of this type.*

29 In addition to observing the above conditions, special care must be taken whenever the sensor is serviced.

a) The oxygen sensor has a permanently attached pigtail and electrical connector which should not be removed from the sensor. Damage or removal of the pigtail or electrical connector can adversely affect operation of the sensor.

b) Grease, dirt and other contaminants should be kept away from the electrical connector and the louvred end of the sensor.

c) Do not use cleaning solvents of any kind on the oxygen sensor.

d) Do not drop or roughly handle the sensor.

e) The silicone boot must be refitted in the correct position to prevent the boot from being melted and to allow the sensor to operate properly.

Check

Note: Access to the oxygen sensor makes it very difficult but not impossible to backprobe the harness electrical connectors for testing purposes. The exhaust manifolds and pipes are extremely hot and will melt stray electrical probes and leads that touch the surface during testing. If possible, use a SCAN tool that plugs into the DLC (Data Link Connector). This tool will access the PCM data stream and indicates the millivolt changes for each individual oxygen sensor.

30 Check the oxygen sensor millivolt signal. Locate the oxygen sensor electrical connector and carefully backprobe it using a long pin(s) into the appropriate wire terminals:

Refit the positive probe of a voltmeter onto the signal wire pin and the negative probe to earth.

Note: There is one signal wire and one earth wire in each oxygen sensor. Consult the wiring diagrams at the end of Chapter 12 for additional information on the oxygen sensor electrical connector wire colour designations.

Monitor the voltage signal (millivolts) as the engine goes from cold to warm.

31 The oxygen sensor will produce a steady voltage signal of approximately 0.1 to 0.2 volts with the engine cold (open loop). After a period of approximately two minutes, the engine will reach operating temperature and the oxygen sensor will start to fluctuate between 0.1 to 0.9 volts (closed loop). If the oxygen sensor fails to reach the closed loop mode or there is a very long period of time until it does switch into closed loop mode, renew the oxygen sensor.

32 If the oxygen sensor fails any of these tests, renew it.

Renewal

Note: Because it is refitted in the exhaust manifold or pipe, which contracts when cool, the oxygen sensor may be very difficult to loosen when the engine is cold. Rather than risk damage to the sensor (assuming you are planning to reuse it in another manifold or pipe), start and run the engine for a minute or two, then shut it off. Be careful not to burn yourself during the following procedure.

33 Disconnect the earth (-) lead from the battery.

Caution: On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).

34 Raise the vehicle and place it securely on jackstands.

35 Carefully disconnect the electrical connector from the wiring harness.

36 Carefully unscrew the sensor from the exhaust manifold or pipe.

37 Anti-seize compound must be used on the threads of the sensor to facilitate future removal. The threads of new sensors will already be coated with this compound, but if an old sensor is removed and refitted, re-coat the threads.

38 Refit the sensor and tighten it securely.

39 Reconnect the electrical connector of the pigtail lead to the main engine wiring harness.

40 Lower the vehicle, take it on a test drive and check to see that no trouble codes set.

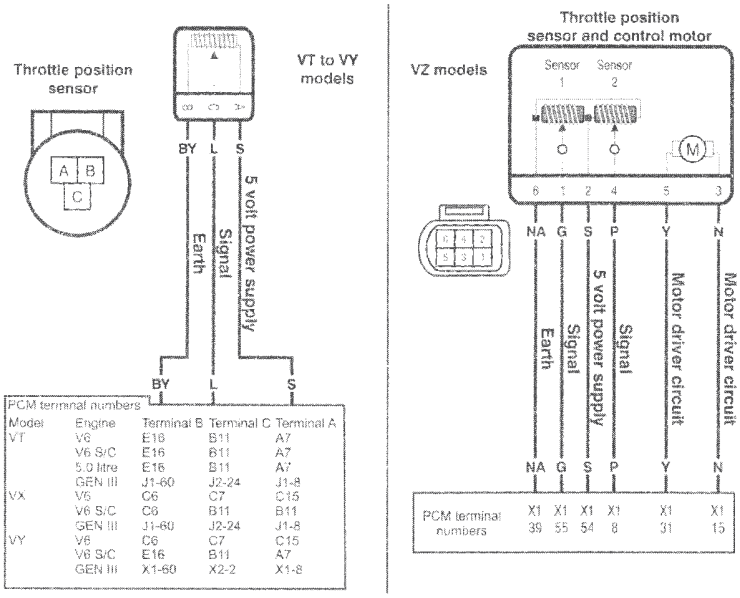
THROTTLE POSITION SENSOR (TPS)

General description

Refer to illustration 4.41

41 The Throttle Position Sensor (TPS) is located on the end of the throttle shaft on the throttle body (see illustration). By monitoring the output voltage from the TPS, the PCM can determine fuel delivery based on throttle valve angle (driver demand). A broken or loose TPS can cause intermittent bursts of fuel from the injector and an unstable idle because the PCM thinks the throttle is moving.

Note: Some models have an electronic throttle. These are determined by the absence of a throttle cable. A sensor on the throttle pedal signals to the PCM the driver's demand (if the throttle is being depressed and how far). The PCM then drives an electric motor on the end of the throttle shaft on the throttle body. The motor will open the throttle valve in proportion to the driver's demand. A throttle position sensor is incorporated in the throttle control motor assembly and signals the PCM with the actual position of the throttle valve. When testing this type of throttle position sensor, a scan tool must be used (see Step 45).



4.43 Throttle position sensor wiring diagrams. VZ V6 models are drawn on the RH side of the illustration. VZ V8 models are similar. Note that the connectors are drawn as if looking into the rear of the wiring connectors

42 A problem in any of the TPS circuits will set a code. Once a trouble code is set, the PCM will use an artificial default value for TPS and some vehicle performance will return.

Check

Refer to illustration 4.43

43 Locate the Throttle Position Sensor (TPS) on the throttle body. Using a voltmeter, check the REFERENCE voltage from the PCM (see illustration). Connect the positive probe (+) onto the REFERENCE wire and negative probe (-) onto the earth wire. The voltage should read approximately 5.0 volts.

44 Next, check the TPS signal voltage. With the throttle fully closed, connect the positive probe (+) of the voltmeter onto the signal wire (the A terminal) and the negative probe (-) onto the earth wire (the B terminal). Gradually open the throttle valve and observe the TPS sensor voltage. Observe a smooth change in the voltage values as the sensor travels from idle to full throttle. The voltage should increase to approximately 4.5 to 5.0 volts. If the readings are incorrect, renew the TPS sensor.

45 An alternate method of diagnosing the TPS sensor is by the use of an electronic SCAN tool. Refit the SCAN tool and switch to the TPS mode and monitor the voltage signal with the engine at idle and high rpm. The SCAN tool should indicate between 1.2 to 1.6 volts at idle. Raise the engine rpm and observe that as engine rpm increases (throttle angle) the TPS voltage increases to approximately 4.5 to 5.0 volts. If the TPS sensor voltage readings are incorrect, renew the TPS sensor.

Renewal

3.8 Litre V6 non-supercharged models

46 Remove the necessary engine trim covers. Disconnect the electrical connector from the TPS.

47 Remove the bolts from the TPS and remove the TPS from the throttle body (see illustration 4.41). Remove the plastic adapter from the end of the throttle shaft.

48 To renew the TPS, turn it 30 degrees clockwise before placing it on the adapter and the throttle shaft. After it in is place, rotate it 30 degrees anticlockwise to its normal position.

49 The remainder of the refitting is the reverse of removal.

V6 supercharged models

50 Remove the necessary engine trim covers.

51 Disconnect the air inlet duct from the throttle body (refer to Chapter 4).

52 Disconnect both cables from the throttle body (refer to Chapter 4).

53 Remove the cable bracket from the throttle body.

54 Disconnect the electrical connector from the TPS.

55 Remove the bolts from the TPS and remove the TPS from the throttle body (see illustration 4.41). Remove the plastic adapter from the end of the throttle shaft.

56 To renew the TPS, turn it 30 degrees clockwise before placing it on the adapter and the throttle shaft. After it is in place, rotate it 30 degrees anticlockwise to its normal position.

57 The remainder of the refitting is the reverse of removal.

5.0 Litre V8 models

58 Remove the throttle body assembly from the vehicle (refer to Chapter 4).

59 Remove the throttle position sensor screws (see illustration 4.41).

60 Carefully lift the sensor from the throttle body. Take care to not drop the drive adapter parts.

61 Remove the drive adapter, the two washers and the spring from the throttle body.

62 To refit the sensor, first install the washer, the spring, the second washer and the drive adapter into the throttle body.

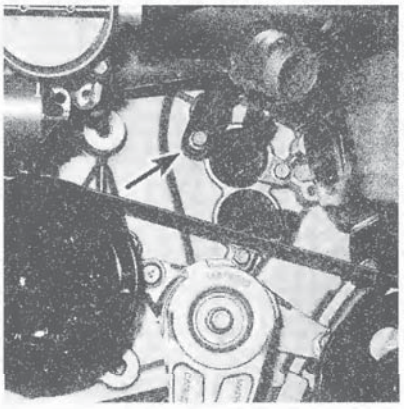
63 Close the throttle.

64 Rotate the sensor 30 degrees clockwise from its normal position and refit it. After it is seated, rotate it 30 degrees anticlockwise to its normal position.

65 The remainder of refitting is the reverse of removal.

4.67 The air conditioning refrigerant pressure sensor (arrow)

4.76a 3.8 litre V6 engines use a camshaft position sensor (arrow) located near the crankshaft sensor on the front of the engine



4.76b 3.6 litre V6 engines have four camshaft position sensors, one for each camshaft. One of the sensors is illustrated by the arrow

AIR CONDITIONING REFRIGERANT PRESSURE SENSOR

Refer to illustration 4.67

66 During air conditioning operation, the PCM controls the application of the air conditioning compressor clutch. The PCM controls the air conditioning clutch control relay to delay clutch engagement after the air conditioning is turned ON to allow the IAC valve to adjust the idle speed of the engine to compensate for the additional load. The PCM also controls the relay to disengage the clutch on WOT (wide open throttle) to prevent excessively high rpm on the compressor. A problem in the air conditioning clutch control circuits will set a code. Be sure to check the air conditioning system as detailed in Chapter 3 before attempting to diagnose the air conditioning clutch or electrical system.

67 The air conditioning refrigerant pressure sensor is located at the left front of the engine compartment in the refrigerant line (see illustration).

Air conditioning "On" signal

68 Turning on the air conditioning supplies battery voltage to the air conditioning compressor clutch and the PCM electrical connector to increase idle air rate and maintain idle speed. In most cases, if the air conditioning does not function, the problem is probably related to the air conditioning system relays and switches and not the PCM.

69 Remove the air conditioning relay from the relay centre and check for battery voltage to the relay. Battery voltage should exist with the ignition key ON (engine not running).

70 If battery voltage exists, refit a jumper wire into the relay connector and observe that the air conditioning clutch activates. If the air conditioning clutch and relay system are working properly, check the air conditioning system pressures (see Chapter 3).

Note: *On vehicles equipped with electronic climate control, the A/C request command is a function of the inside air temperature sensor as well.*

VEHICLE SPEED SENSOR (VSS)

General description

71 The Vehicle Speed Sensor (VSS) is located in the transmission housing at the rear section near the output shaft. This permanent magnet generator sends a pulsing voltage signal to the PCM, which the PCM converts to kilometres per hour. The VSS is part of the Transmission Converter Clutch (TCC) system. A problem in the VSS control circuit will set a code.

Check

72 To check the VSS, disconnect the electrical connector in the wiring harness near the sensor, raise the vehicle and support it securely on jackstands. Connect a voltmeter to the two VSS terminals and set it to the AC scale. Put the transmission in Neutral. Rotate the drive wheels by hand (the driveshaft must turn) and note the meter reading. It should fluctuate from zero to 0.5 volts.

Renewal

73 Raise the vehicle and support it securely on jackstands.

74 Disconnect the wiring harness from the sensor, releasing the clip with a small screwdriver. The sensor will have to be pried out with a screwdriver. It is best to place a drain pan under the sensor to catch transmission fluid first.

75 Refitting is the reverse of removal. Be sure to apply a little transmission fluid to the sensor O-ring first.

CAMSHAFT SENSOR (EXCEPT 5.0L V8 MODELS)

General description

Refer to illustrations 4.76a and 4.76b

Note: *5.0 litre V8 engines use camshaft and crankshaft position sensors incorporated into the distributor assembly. See Chapter 5 for information on the distributor.*

76 The 3.8 litre V6 camshaft sensor is located in the top section of the timing chain cover directly behind and below the water pump (see illustration). The 3.6 litre V6 has four camshaft sensors. One for each camshaft. They are located at the front of the engine (see illustration). As the camshaft turns,

a magnet on the camshaft activates the Hall-effect switch in the sensor. This signal is used by the PCM to synchronise the fuel injection system with the opening of the inlet valves. In the event the reference signal is lost or interrupted, the PCM will continue to pulse the fuel injectors using a default value but the synchronising effect may be slightly off due to the lack of precision. If the cam signal is not received by the PCM, a code will set.

Check

Refer to illustration 4.78

77 To check the cam sensor circuit, disconnect the cam sensor electrical connector. Turn the ignition key to ON but do not start the engine.

78 Measure the voltage to the sensor at terminal C (see illustration). The voltage should be 12 volts on 3.8 litre V6 and 5.7 litre Gen III models. The voltage should be 5 volts on 3.6 litre V6 and 6.0 litre Gen IV models. Check that there is continuity to earth at terminal B.

79 If there is no voltage present, check the ignition fuse in the fuse box. If the fuse is good, check the circuit between the cam sensor and the fuse box, ignition module or PCM. Also check the earth circuit from the sensor to the PCM or ignition module. Re-connect the wiring to the camshaft position sensor.

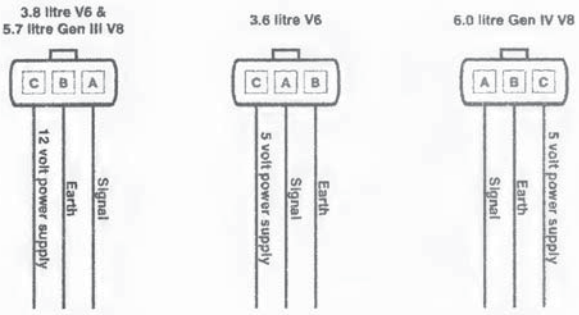
> ***Note:*** *3.6 litre models have four camshaft position sensors. Each one shares the same power supply and earth circuits. If there is a short circuit in one of the sensors, it is probable that it will prevent each sensor from working.*

80 Relieve the fuel system pressure (see Chapter 4, Section 2). Backprobe the signal circuit wire (terminal A) with the positive probe of a voltmeter, connect the negative probe to a good engine earth.

81 Crank the engine and check for any type of fluctuating signal from the sensor.

82 If the sensor signal voltage is not correct, the sensor is probably defective. Have the cam sensor diagnosed by a dealer service department or other qualified repair shop.

83 It's also possible to observe the actual camshaft sensor signal while the engine is running. A SCAN tool is available from automotive parts stores and specialty tool companies that can be plugged into the DLC for the purpose of monitoring the computer and the sensors. Refit the SCAN tool and switch to the Camshaft sensor mode and monitor the voltage signal from the cam sensor.



4.78 Camshaft position sensor terminal details. Note that the illustration is drawn as if looking into the rear of the wiring connectors while connected to the sensor.

Renewal

84 Remove components necessary to access the camshaft sensor.

85 Disconnect the electrical connector from the cam sensor.

86 Remove the bolt from the camshaft sensor and pull the sensor from the timing cover.

87 Refitting is the reverse of removal. Be sure to tighten the camshaft sensor bolt to the torque listed in this Chapter's Specifications.

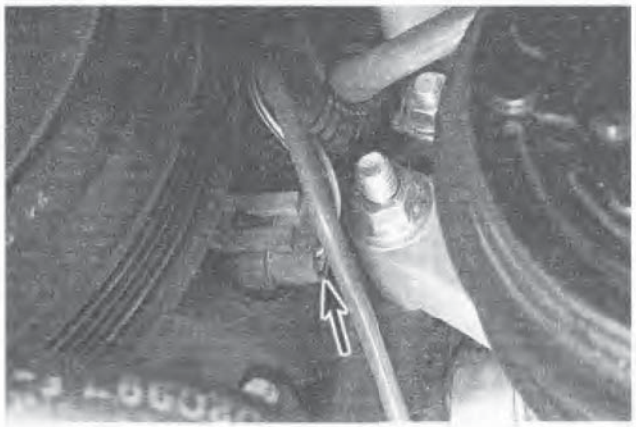
CRANKSHAFT SENSOR (EXCEPT 5.0L V8 MODELS)

General description

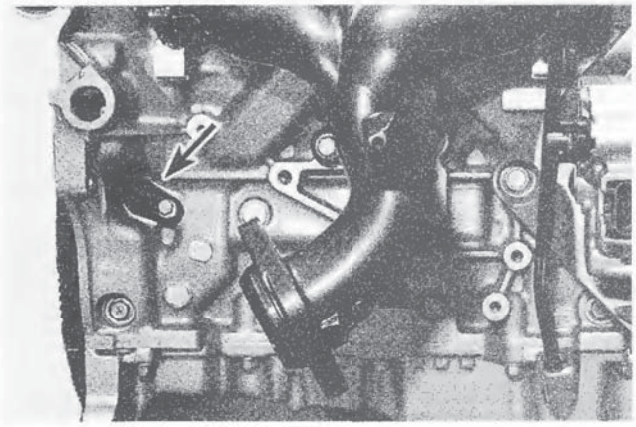
Refer to illustrations 4.88a and 4.88b

> ***Note:*** *5.0 litre V8 engines use camshaft and crankshaft position sensors incorporated into the distributor assembly. See Chapter 5 for information on the distributor.*

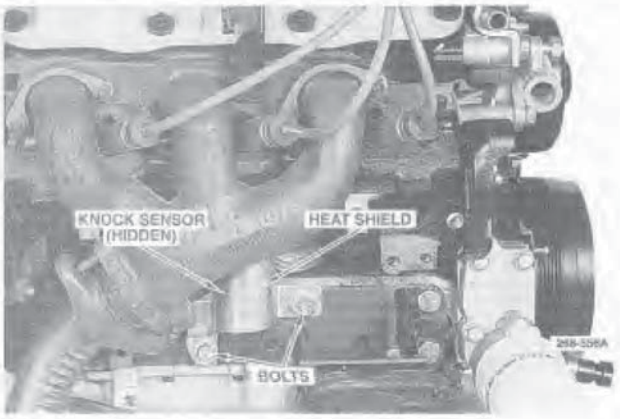
88 This sensor is a Hall-effect switch, it is equipped with a magnet. The magnet and the Hall-effect switch are separated by an air gap. The sensor is located behind the vibration damper and the vibration damper is equipped with specially designed blades or "interrupter rings" to create the



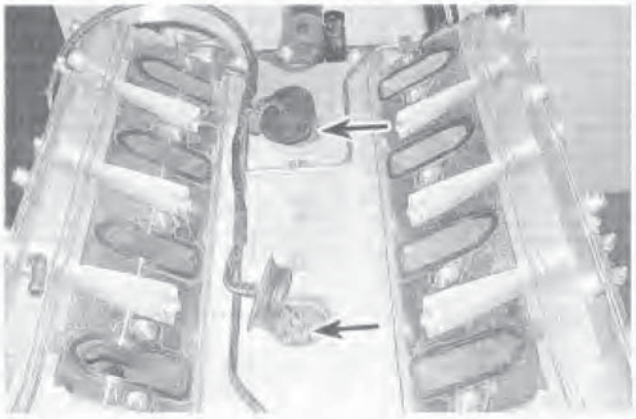
4.88a The crankshaft position sensor is located behind the crankshaft balancer on 3.8 litre V6 models



4.88b On 3.6 litre V6 engines, 5.7 litre Gen III and 6.0 litre Gen IV models, the crankshaft position sensor is on the rear of the cylinder block



4.96a V6 engine knock sensor location



4.96b 5.7 litre Gen. III V8 engine knock sensors locations (arrows)

ON-OFF-ON pulses necessary for the timing sequence (see illustrations). Although there is not an ignition timing procedure for the DIS system, the position of the crank sensor is very important. The sensor must not contact the rotating interrupter rings or the sensor will be damaged and the engine will shut down.

Check

89 To check the crankshaft sensor, it is necessary to use a special SCAN tool. Have the sensor diagnosed by a dealer service department or other qualified repair shop.

Renewal

90 Disconnect the negative terminal from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

91 Remove the serpentine drivebelt (see Chapter 1).

92 Disconnect the electrical connector from the crankshaft sensor.

93 Remove the crankshaft vibration damper retaining bolt and damper (see Chapters 2A, 2B or 2D).

94 Remove the protector and bolts from the crankshaft sensor and lift the sensor from the timing cover.

95 Refitting is the reverse of removal. Tighten the bolts to the torque listed in this Chapter's Specifications.

KNOCK SENSOR

General description

Refer to illustrations 4.96a and 4.96b

96 Two knock sensors are used on all models except the 5.0 litre V8 engines, which has a single knock sensor on the side of the engine block very near the sump rail. The sensors on V6 engines are threaded into the engine block water jackets - one on each side of the engine about 50 mm above the sump rail (see illustrations). The 5.7 litre Gen III and 6.0 litre Gen IV model's sensors are located in the valley cover below the inlet manifold.

97 Octane ratings vary the performance of engines, and often detonation leads to "spark knock". To control spark knock, the knock control system detects abnormal vibration in the engine. This system is designed to reduce spark knock up to 10 degrees during periods of heavy detonation. This allows the engine to use maximum spark advance to improve driveability. The knock sensor produces an AC output voltage which increases with the severity of the knock. The signal is fed into the PCM and the timing is retarded up to 10 degrees to compensate for the severe detonation. Any problems with the knock sensor circuit will set a code.

Check

98 Have an assistant run the engine steadily at about 1700 RPM.

99 Make sure the DLC connector is in the normal driving mode.

100 To accurately assess the knock sensor operation, a scan tool is required. On some models it is possible to tap on the engine block near the knock sensor with a hammer and note if the RPM drops slightly as the sensor detects a shock wave.

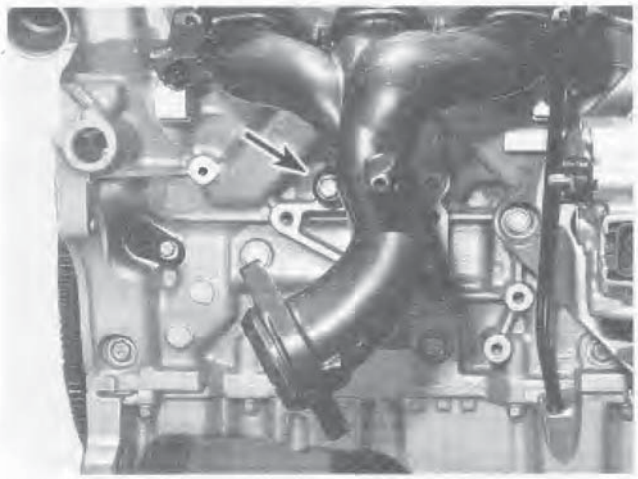
Renewal

V6 and 5.0 litre V8 models

Refer to illustrations 4.102 and 4.105

101 Raise the vehicle and support it securely on jackstands.

102 On 3.6 litre V6 models, remove the front engine pipe (see Chapter 2B). Remove the bolt and disconnect the knock sensor wiring (see illustration).



4.102 Arrow indicates RH knock sensor location on 3.6 litre V6 engines

103 On 3.8 litre V6 and 5.0 litre V8, make sure that the engine is cool. Remove the radiator cap and drain the cooling system.

104 Disconnect the wiring connector from the sensor.

105 Remove the heat shield (see illustration). Put a drain pan under the sensor.

106 Unscrew the sensor. The remainder of refitting is the reverse of removal.

Renewal

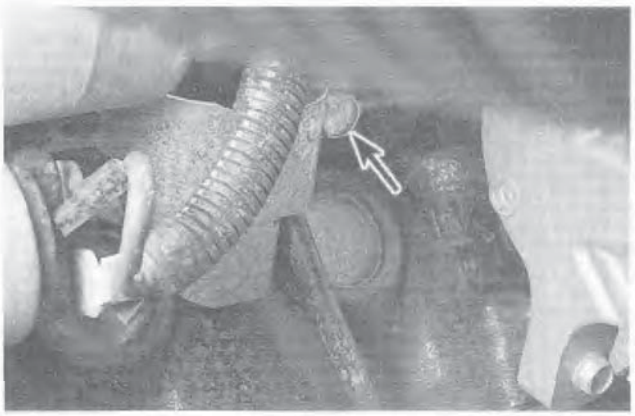
5.7 litre Gen III and 62.0 litre Gen IV V8 models

107 Remove the inlet manifold (see Chapter 2D).

108 Detach the grommets from the valley cover, pull the grommets up and disconnect the electrical connectors from the knock sensors. Remove the wiring harness.

109 Remove the knock sensors from the engine block.

110 Refitting is the reverse of removal.



4.105 Remove the knock sensor heat shield bolt (arrow)

5 Evaporative Emissions Control System (EECS)

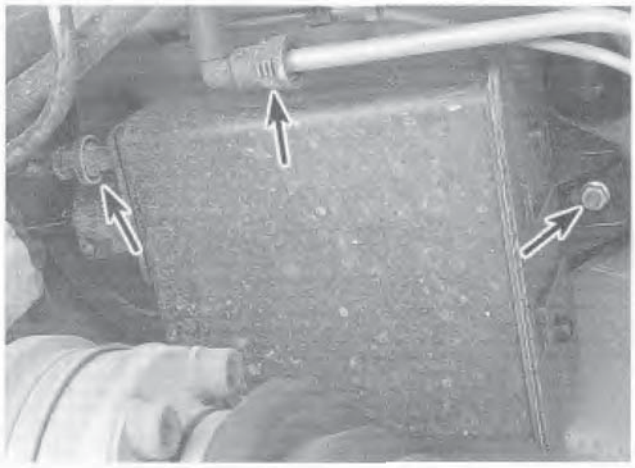
GENERAL DESCRIPTION

Refer to illustration 5.2

1 This system is designed to trap and store fuel that evaporates from the throttle body and fuel tank which would normally enter the atmosphere and contribute to hydrocarbon (HC) emissions.

2 The system consists of a charcoal-filled canister mounted under the rear axle centre section near the fuel filter (see illustration). The system lines run to and from the canister and include a vent line from the fuel tank, a vent line from the throttle body and a purge line to the inlet manifold. A canister purge solenoid (located at the rear of the right cylinder head) is controlled by the PCM to regulate the flow of vapour to the throttle body for combustion. The fuel tank cap is also an integral part of the system.

3 An indication that the system is not operating properly is a strong fuel odour.



5.2 The canister, located under the rear axle centre section, is held in place by a nut (right arrow) and uses quick-connect fittings (arrows) (push in on the hose while squeezing the fitting to release the tabs)

CANISTER CHECK

4 Raise the vehicle and support it securely on jackstands.

5 Check all lines in and out of the canister for kinks, leaks and breaks along their entire lengths. Repair or renew as necessary. Also check the hoses at the canister purge control solenoid.

6 Check the gasket in the fuel tank cap for signs of drying, cracking or breaks. Renew the fuel tank cap if defects are found.

CANISTER RENEWAL

7 Raise the vehicle and support it securely on jackstands. Locate the canister near the fuel filter. Clean any dirt from around the hose fittings.

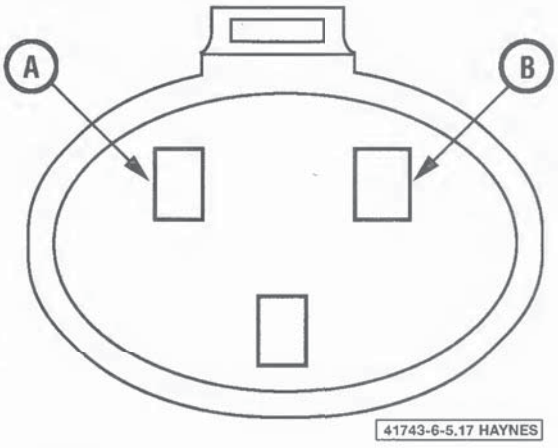
8 Disconnect the vapour inlet hose by pushing it towards the canister and squeezing the tabs on the quick-connect fitting (see illustration 5.2). Pull the fitting from the canister.

9 Disconnect the vapour purge hose by using the same method.

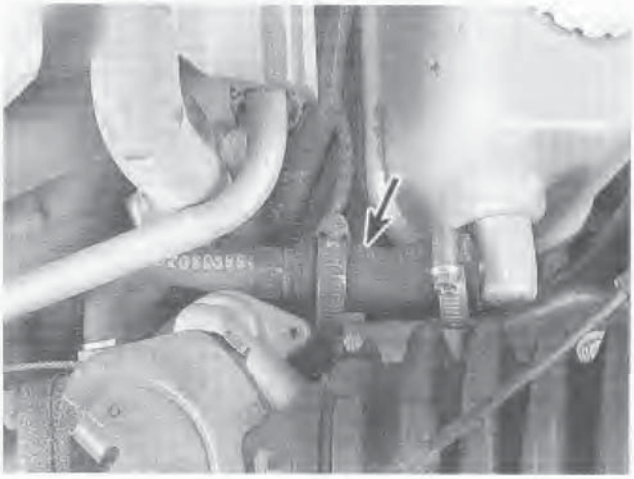
10 Disconnect the vent hose.

11 Remove the mounting nut and lower the canister from its bracket.

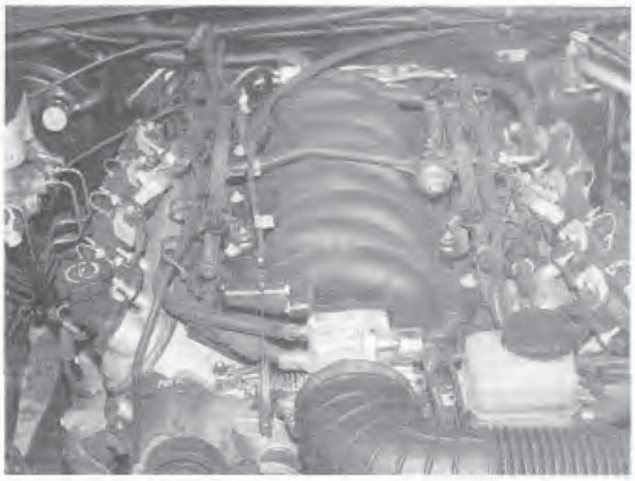
12 Refitting is the reverse of removal.



5.17 Canister purge control solenoid electrical connector details



6.2a The 5.0 litre V8 PCV valve is located in a hose connected to the right valve cover



6.2b The 5.7 litre Gen III V8 PCV valve is located in a hose connected to the throttle body

13 When renewing any line running to or from the canister, make sure the renewal line is a duplicate of the one you are renewing. These lines are often colour coded to denote their particular usage.

CANISTER PURGE CONTROL SOLENOID CHECK

Refer to illustration 5.17

14 Disconnect the wiring harness from the solenoid.

15 Turn the ignition ON. Make sure the engine is not running.

16 Using a test light, verify that there is voltage to one terminal of the wiring harness. This power comes from the PCM.

17 Disconnect the wiring harness. Use jumper wires to earth terminal B and reconnect terminal A to its power source (see illustration). Disconnect, then reconnect the earth wire. The solenoid should click each time. If it does not, renew it.

18 Check for an open in the wire to the PCM.

CANISTER PURGE CONTROL SOLENOID RENEWAL

19 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

20 Label the hoses and disconnect them from the solenoid.

21 Disconnect the wiring harness from the solenoid.

22 Unbolt the solenoid from the cylinder head.

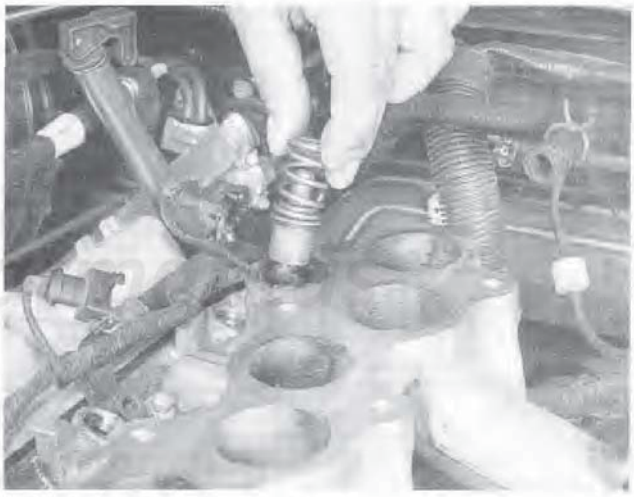
23 Refitting is the reverse of removal.

6 Positive Crankcase Ventilation (PCV) system

GENERAL DESCRIPTION

Refer to illustrations 6.2a, 6.2b and 6.2c

1 The positive crankcase ventilation system reduces hydrocarbon emissions by circulating fresh air through the crankcase to pick-up blow-by gases, which are then rerouted through the throttle body to be burned in the engine.



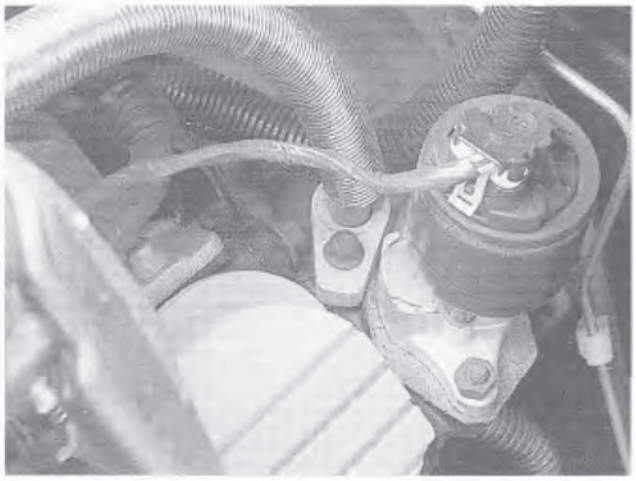
6.2c The PCV valve used on non-supercharged engines is mounted in the inlet manifold

2 The main components of this system are vacuum hoses and a PCV valve, which regulates the flow of gases according to engine speed and manifold vacuum.

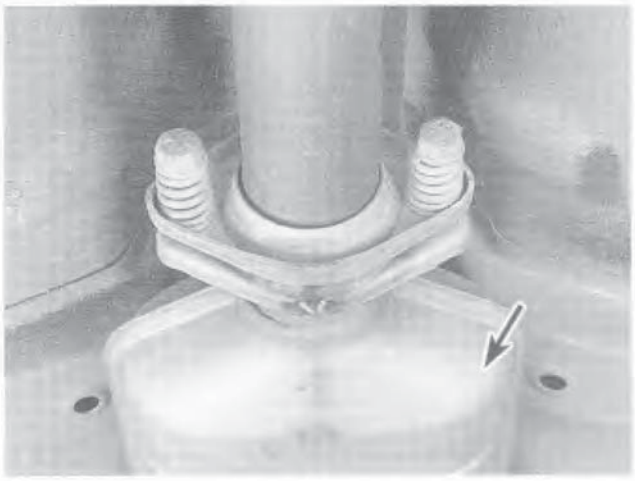
> ***Note:*** *The PCV valve for V8 engines is mounted in the hose which connects the right valve cover and the throttle body (see illustrations). The PCV valve for non-supercharged 3.8 litre V6 engines is fitted in the upper right rear of the lower inlet manifold (see illustration). Supercharged V6 engines have the PCV valve at the upper right rear of the engine in a housing which is level with the top of the supercharger. 3.6 litre V6 engines have the PCV valve in the LH rocker cover at the rear of the engine.*

CHECK AND COMPONENT RENEWAL

3 Checking the system and PCV valve renewal are covered in Chapter 1.



8.5 The linear EGR valve controls the flow of exhaust gas to the inlet



9.3 Check the catalytic converter (arrow) carefully for damage especially if the vehicle has been used in rough terrain

7 Transmission Converter Clutch (TCC) system

GENERAL INFORMATION

1 The purpose of the Torque Converter Clutch (TCC) system, equipped in automatic transmissions, is to eliminate the power loss of the torque converter stage when the vehicle is in the cruising mode (usually above 80 kph). The lock-up mode is controlled by the PCM through the activation of the TCC apply solenoid which is built into the automatic transmission. When the vehicle reaches a specified speed, the PCM energises the solenoid and allows the torque converter to lock-up and mechanically couple the engine to the transmission, under which conditions emissions are at their minimum. However, because of other operating condition demands (deceleration, passing, idle, etc.), the transmission must also function in its normal, fluid-coupled mode. When such latter conditions exist, the solenoid de-energises, returning the torque converter to normal operation. The converter also returns to normal operation whenever the brake pedal is depressed.

CHECK

2 Due to the requirement of special diagnostic equipment for the testing of this system, and the possible requirement for dismantling of the automatic transmission to renew components of this system, checking and renewing of the components should be handled by a dealer service department or other qualified repair facility.

8 Exhaust Gas Recirculation (EGR) system

Note: This system is used on 3.8 litre V6 models only.

GENERAL INFORMATION

1 This system meters small amounts of exhaust gases into the engine induction system through a linear EGR valve. From there the exhaust gases pass into the fuel/air mixture for the purpose of lowering combustion temperatures, thereby reducing the amount of oxides of nitrogen (NOx) formed.

2 The amount of exhaust gas admitted is regulated by a linear EGR valve which is in turn controlled by the PCM. The PCM uses information from several sensors to make its command to the EGR valve.

3 Common problems with the EGR system include rough idling, stalling during deceleration and rough engine performance during light acceleration.

CHECK

4 Due to the requirement of special diagnostic equipment for the testing of this system, checking and renewing of the components should be handled by a dealer service department or other qualified repair facility.

EGR VALVE RENEWAL

Refer to illustration 8.5

5 The EGR valve is mounted to the rear of the left cylinder head (see illustration).

6 Remove the engine trim cover.

7 Disconnect the wiring harness from the valve.

8 Unbolt the EGR valve and remove it along with its gasket.

9 Refitting is the reverse of removal.

9 Catalytic converter

GENERAL DESCRIPTION

1 The catalytic converter is an emission control device added to the exhaust system to reduce pollutants from the exhaust gas stream. These systems are equipped with a single bed monolith catalytic converter. This monolithic converter contains a honeycomb mesh which is also coated with two types of catalysts. One type is the oxidation catalyst while the other type is a three-way catalyst that contains platinum and palladium. The three-way catalyst lowers the levels of oxides of nitrogen (NOx) as well as hydrocarbons (HC) and carbon monoxide (CO) emissions. The oxidation catalyst lowers the levels of hydrocarbons and carbon monoxide.

CHECK

Refer to illustration 9.3

2 The test equipment for a catalytic converter is expensive and highly sophisticated. If you suspect the converter is malfunctioning, take it to a dealer service department or authorised emissions inspection facility for diagnosis and repair.

3 Whenever the vehicle is raised for service of underbody components, check the converter for leaks, corrosion and other damage (see illustration). If damage is discovered, the converter should be renewed.

4 Because the converter is welded to the exhaust system, converter renewal requires removal of the exhaust pipe assembly (see Chapter 4). Take the vehicle, or the exhaust system, to a dealer service department or a muffler shop.

Notes

Chapter 7
Transmission

Part A Manual transmission

Contents

Specifications

Models

3.8 litre V6 models	Getrag Type 260
3.6 litre V6 models	Aisin Type D173
5.0 litre V8 models	Getrag Type 290
5.7 litre Gen III V8 and 6.0 litre Gen IV V8 models	Tremac Type T56

Lubricants

Type	
3.8L V6 and 5.0L V8	80W gear oil
3.6L V6	75W/90 GL5
5.7L Gen III and 6.0L Gen IV V8	DEXRON III Automatic Transmission Fluid (ATF)
Capacity	
Except 5.7L Gen III and 6.0L Gen IV V8	Up to 2.0 litres
5.7L Gen III and 6.0L Gen IV V8	4.4 litres

Synchromesh assemblies

Ring wear clearance	
Getrag Type 260	
New	1.0 to 1.3 mm
Wear limit	1.0 mm or less
Getrag Type 290	
New	1.35 to 1.95 mm
Wear limit	
Forward gears	1.35 mm or less
Reverse gear	1.0 mm or less

Synchromesh assemblies (continued)

Tremac Type T56	
Wear limit	
Forward gears	0.38 mm or less
Reverse gear	0.75 mm or less
Ring identification	
Getrag Type 260	
1st/2nd	040.8.0001.00
3rd/4th	002.8.0301.00
5th/reverse	011.8.0331.10 or 011.8.0331.11
Getrag Type 290	
All forward gears	0058.8.5031.02
Reverse gear	0058.8.5111.00

Endfloat clearance

Getrag Type 260	
Maindrive gear	0.00 to 0.9 mm
Cluster gear	0.13 mm to 0.23 mm
Getrag Type 290	
Cluster gear	0.12 to 0.22 mm
Reverse idler gear	0.05 to 0.55 mm
Tremac Type T56	
Bearing Pre-Load/End Float:	
Input Shaft/Mainshaft	0.00 to 0.05 mm pre-load
Countershaft Gear	0.00 to 0.05 mm pre-load
Countershaft Gear Extension	0.05 to 0.13 mm end float

Selective snap-ring thickness

Getrag Type 260	
3rd/4th synchromesh assembly	2.0, 2.1, 2.2, 2.3, 2.4, 2.5 mm
1st/ 2nd synchromesh assembly	1.8, 1.85, 1.9, 1.95, 2.0 mm
5th/reverse synchromesh assembly	1.8, 1.85, 1.9, 1.95, 2.0 mm
Getrag Type 290	
3rd/4th synchromesh assembly	1.80, 1.85, 1.90, 1.95, 2.00 mm
2nd gear bearing/thrust sleeve	2.00, 2.05, 2.10, 2.15, 2.20, 2.25, 2.30 mm
5th/reverse synchromesh assembly	2.00, 2.05, 2.10, 2.15, 2.20 mm
Rear mainshaft bearing	2.00, 2.10, 2.20, 2.30 mm

Selective spacer/shim washer thickness

Getrag Type 260
- Throw out bearing guide-to-input shaft bearing ..... 0.3, 0.4, 0.5 mm
- Input shaft bearing ..... 2.1, 2.2, 2.3, 2.4, 2.5 mm
- Cluster gear endfloat adjustment ..... 1.0, 1.7, 1.8, 2.0, 2.1, 2.2, 2.3 mm

Getrag Type 290
- Maindrive gear spacer washer ..... 2.10, 2.20, 2.30, 2.40, 2.50 mm
- Maindrive gear bearing spacer shim ..... 0.30, 0.40, 0.50 mm
- Cluster gear endfloat adjustment ..0.30, 0.40, 0.50, 2.30, 2.35, 2.40, 2.45, 2.50 mm

Tremac Type T56
- Input Shaft Bearing ..... 0.559 to 1.372 mm
- Countershaft Gear ..... 0.356 to 1.372 mm
- Countershaft Gear Extension ..... 0.559 to 1.372 mm

Torque specifications

	Nm
Back-up light switch	
Getrag	20
Aisin	44
Tremec Type T56	28
Crossmember-to-frame bolts	
Getrag	50 to 65
Aisin	58
Crossmember-to-rear mount nuts	
Getrag	20 to 30
Aisin	25
Tremec Type T56	50
Drain plug	
Getrag	40 to 60
Aisin	37
Tremec Type T56	28
Fill plug	
Getrag Type 260	40 to 60
Getrag Type 290	25
Aisin	37
Tremec Type T56	28
Flywheel cover screws	
Getrag	5 to 10
Aisin	14
Tremec Type T56	12
Locking lever screw plug	
Getrag Type 260	48
Getrag Type 290	60
Rear housing-to-transmission bolts and nuts	
Getrag	25
Aisin	29
Tremec Type T56	35
Speed sensor-to-bracket screw	6 to 14
Speed sensor bracket-to-transmission bolt	6 to 14
Transmission-to-engine bolts	
Getrag	50 to 85
Aisin	55
Tremec Type T56	50

1 General information

Refer to illustrations 1.1a and 1.1b

The vehicles covered by this manual are equipped with a five or six-speed manual transmission or a four or five-speed automatic transmission. Information on the manual transmission is included in this part of Chapter 7. You'll find information on the automatic transmission in Part B of this Chapter.

Models with the 3.8 litre V6 and 5.0 litre V8 engines use the Getrag five-speed transmissions (see illustrations 1.1a and 1.1b). The V6 engine uses the Getrag type 260 while the 5.0 litre V8 models are equipped with the type 290. The two types are virtually the same in design, with the main differences being in the tailshaft housing details. These transmissions do not require shift linkage adjustment because there is no shift linkage. The shift lever, which is mounted on top of the extension housing, can be unbolted and replaced without removing the transmission.

Models with the 3.6 litre V6 engine use a six-speed Aisin transmission. This transmission features 6 fully synchronised forward gears with sixth-gear being the overdrive.

5.7 litre Gen III V8 and 6.0 litre Gen IV V8 models use a six-speed Tremac transmission. This transmission is a fully synchronised unit, including reverse gear, with blocking ring type synchronisers. A triple piece synchroniser assembly is fitted to first and second gears and two piece assemblies are fitted to third, fourth, fifth and sixth gears. Reverse gear is fitted with a single piece blocking ring. The 5.7 litre Gen III V8 transmission uses a roller type spigot bearing, while the 6.0 litre Gen IV V8 transmission uses a sealed ball type spigot bearing. Therefore, a different input shaft is used between the two models and this should be kept in mind if fitting an exchange transmission.

All transmissions are equipped with a back-up light switch and a speed sensor. The procedure for checking and replacing the back-up light switch is in this Chapter. The procedure for checking and replacing the speed sensor is in Chapter 6, Section 4.

2 Shift lever - removal and refitting

ALL MODELS EXCEPT TREMAC TRANSMISSIONS

1 Release each of the eight plastic clips which secure the gearshift lever rubber boot to the console.

2 Grasp the lever and the gearshift knob firmly. Move the knob back and forth while pulling upwards on the boot. Remove the knob/boot assembly from the lever.

3 Raise the vehicle and support it securely on jackstands.

4 Use paint or a scribe to mark the exact position of each end of the rear transmission crossmember where it contacts the frame.

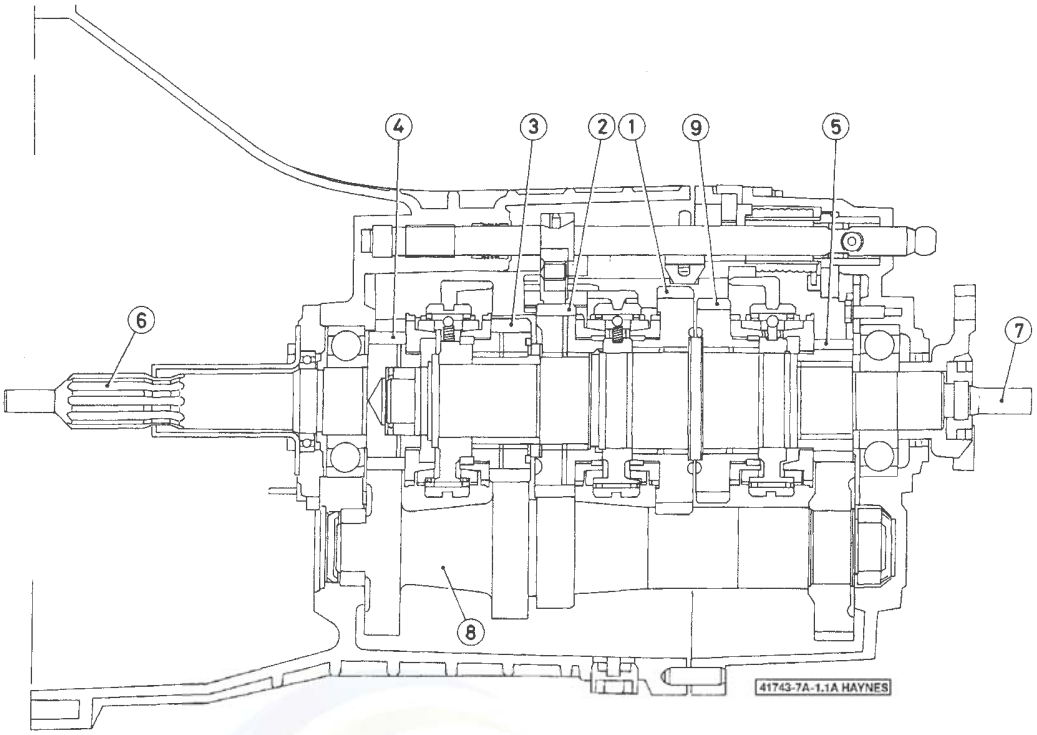
***Caution:** If this is not done, there is a high probability of vibration and/or handling problems after assembly.*

5 Support the rear of the transmission with a floor jack, taking its weight off of the rear mount.

***Note:** Use a block of wood on the jack to avoid damaging the transmission.*

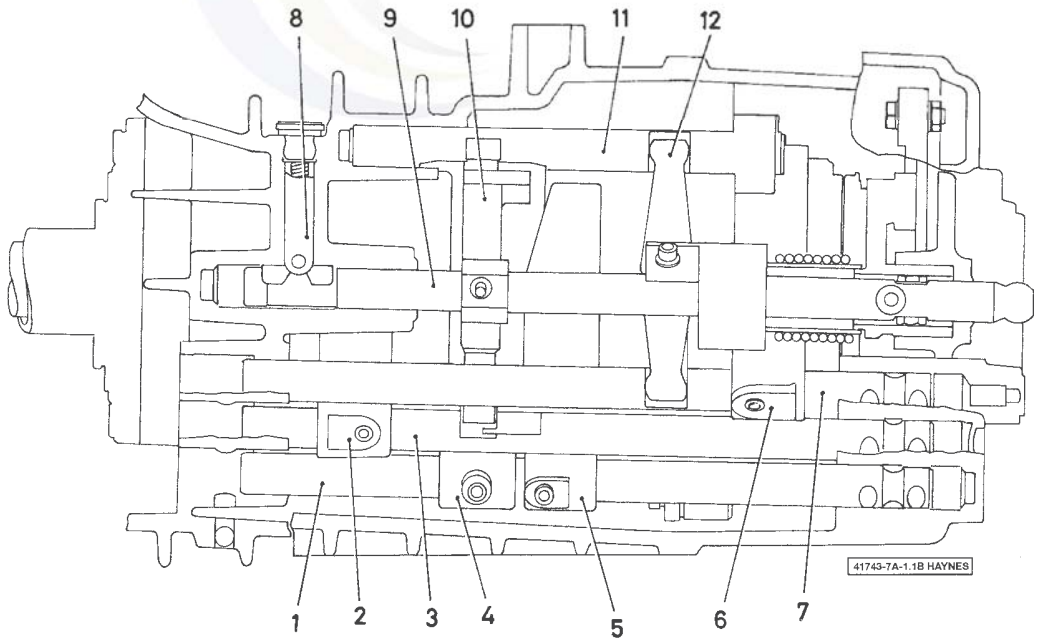
6 Remove the four bolts which secure the crossmember to the frame.

7 Lower the rear of the transmission.



1.1a Sectional view of a typical Getrag 260/290 transmission

1	*1st gear*	*3*	*3rd gear*	*5*	*5th gear*	*7*	*Mainshaft*	*9*	*Reverse gear*
2	*2nd gear*	*4*	*4th gear*	*6*	*Input shaft*	*8*	*Cluster gear*		



1.1b Typical Getrag 260/290 transmission shift selector mechanism

1	*1st/2nd selector rod*	*4*	*Dog*	*7*	*Reverse/5th selector rod*	*10*	*Selector arm*
2	*3rd/4th selector fork*	*5*	*1st/2nd selector fork*	*8*	*Detent (lock) pin*	*11*	*Selector rail*
3	*3rd/4th selector rod*	*6*	*Reverse/5th selector fork*	*9*	*Selector shaft*	*12*	*Operating lever*

8 Remove the pin and the shift linkage brace retainer from the lug on the transmission.
9 Use a screwdriver to pry the shift linkage brace off at the transmission end.
10 Working inside the vehicle, remove the gearshift lever bracket nuts from the console.
11 Remove the E-clip and washer from the shift rod. Pull the shift rod from the lever, taking care to not lose the washer on its end. Note the direction in which the rod enters the lever in case it is later disconnected from the transmission.

Caution: *Refitting the rod in the opposite direction can cause damage to the transmission and difficulty in shifting.*

12 Remove the bolts or nuts which secure the gearshift lever support bracket to the floor.
13 Lower the gearshift assembly and remove it.
14 Refitting is the reverse of removal. If dismantled, lubricate the ball and socket with lithium grease.

TREMAC TRANSMISSIONS

15 Release each of the eight plastic clips which secure the gearshift lever rubber boot to the console.
16 Raise the boot up to the knob to expose two retaining bolts holding the upper shift lever to the lower shift lever. Remove the bolts and remove the upper shift lever, knob and boot as an assembly.

Note: *The gear knob is permanently glued to the lever. The boot can be replaced separately.*

17 Raise the vehicle and support it securely on jackstands.
18 Working beneath the vehicle, remove the nuts securing the shift lever boot retaining plate to the floor. Remove the plate and boot from the vehicle.
19 Further dismantling requires the transmission to be removed from the vehicle.
20 Refitting is the reverse of removal. If dismantled, lubricate the ball and socket with lithium grease.

3 Back-up light switch - check and renewal

CHECK

Note: *The back-up light switch is located on the right side of the transmission housing.*

1 With the engine running and the lights on, depress the clutch and place the shift lever in Reverse. The back-up lights should come on.
2 If the back-up lights don't come on, either a bulb is burned out, there's a short, ground or open in the circuit, or the back-up light switch is bad.
3 Check the bulbs for the back-up light circuit. If either bulb is bad, replace it (see Chapter 12). If the bulbs are good, check the circuit.
4 Using a voltmeter, verify that voltage is getting to the switch and that, when the shift lever is placed in Reverse, there is voltage to the bulbs. If the bulbs are okay and the circuit is okay, check the switch.
5 Raise the vehicle and place it securely on jackstands. Using an ohmmeter, verify that there is continuity through the switch when it's closed, i.e. the shift lever is placed in Reverse. If the switch is bad, replace it.

RENEWAL

6 Raise the vehicle and place it securely on jackstands.
7 Unplug the electrical connector from the back-up light switch.
8 Unscrew the switch.
9 Refitting is the reverse of removal. Be sure to apply a coat of thread sealant or wrap the threads with Teflon tape before fitting the new switch. Tighten the switch to the torque listed in this Chapter's Specifications.

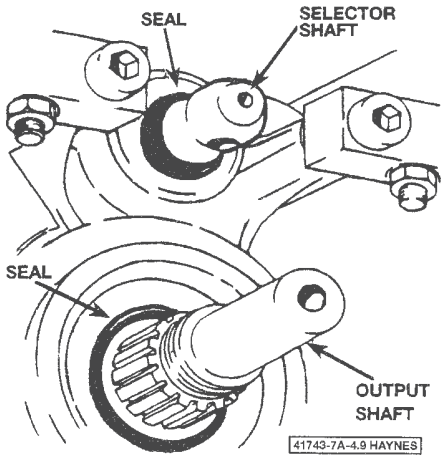
4 Oil seal renewal

Refer to illustrations 4.7 and 4.12

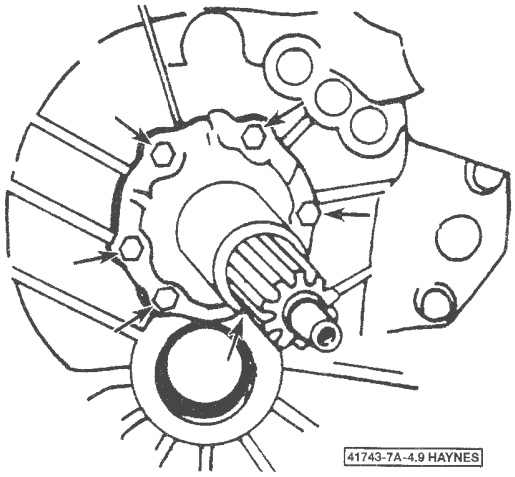
1 Worn or damaged transmission oil seals can cause lubricant leaks. Insufficient lubricant in the transmission can cause hard shifting, jumping out of gear and transmission noise.
2 Most of the transmission seals can be replaced without disassembling the transmission; two of them can be replaced without even removing the transmission.
3 If you suspect a leaking seal, get underneath the transmission and inspect the seals closely. Raise the front of the vehicle and support it securely on jackstands. Be sure to block the rear wheels to keep the vehicle from rolling.
4 If transmission lubricant is coating the front of the driveshaft, either the selector shaft or the output shaft seal is leaking. If you find oil in the bottom of the clutch housing, the input shaft seal may be leaking (of course, the crankshaft rear seal could also cause oil to collect in the bottom of the bellhousing). Whenever you decide to replace a seal, always check the vent on top of the transmission housing first. A clogged or damaged vent can cause pressure inside the transmission to rise enough to pump lubricant past the seals. If you simply replace a seal without cleaning out a clogged vent, the new seal will quickly fail.
5 To replace an output shaft oil seal, remove the driveshaft assembly.

Note: *Depending on the engine/transmission fitted, it may be necessary to remove the exhaust system and support brace to remove the propeller shaft.*

6 On models with a flange, immobilize the flange and remove the flange nut with a thin-walled socket and locking tool. Use a puller tool to remove the flange from the output shaft.
7 Using a seal removal tool or a small screwdriver, carefully prise out the old oil seal (see illustration). Make sure you don't damage the seal bore when you prise out the seal.
8 To renew a selector shaft seal, disconnect the shift rod from the selector shaft, remove the bushing lock ring, then use a small drift punch to drive out the pin.
9 Prise out the selector shaft seal (see illustration 4.7) with a seal removal tool or a small screwdriver. Make sure you don't damage the seal bore while prising out the seal.
10 To renew an input shaft seal, remove the transmission (see Section 5).



4.7 Using a seal removal tool or a small screwdriver, carefully prise out the old output shaft oil seal or selector shaft seal



4.12 Locations of the guide sleeve bolts

11 Remove the clutch release bearing and release lever (see Chapter 8).

12 Remove the bolts for the clutch release guide sleeve (see illustration). Remove the sleeve and any spacers behind it.

13 Using a seal removal tool or a screwdriver, pry out the old seal. Make sure you don't damage the seal bore.

14 When installing any new transmission seal, lubricate the lip of the new seal with oil before driving it into place with a section of pipe of suitable dimensions.

15 Check the transmission lubricant level and add the recommended lubricant (see Chapter 1) as necessary.

16 Lower the vehicle, test drive it and check for leaks.

5 Transmission - removal and refitting

REMOVAL

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Raise the vehicle and place it securely on jackstands.

3 Drain the transmission lubricant (see Chapter 1).

4 Use paint or a scribe to mark the exact position of each end of the rear transmission crossmember where it contacts the frame.

Caution: *If this is not done, there is a high probability of vibration and/or handling problems after assembly.*

5 Support the rear of the transmission with a floor jack, taking its weight off of the rear mount.

Note: *Use a block of wood on the jack to avoid damaging the transmission.*

6 Use a scribe to mark the exact position of the driveshaft centre support bearing bracket and bolts. Remove the bolts and the spacers from the driveshaft centre support bearing.

Caution: *Do not allow the driveshaft to flex more than 8 degrees to avoid damage to the joint or the boot.*

7 Disconnect the driveshaft from the final drive unit (refer to Chapter 8). Discard the lock-nuts.

Note: *Paint alignment marks on the driveshaft flange and the pinion flange prior to disconnecting them.*

8 Remove the driveshaft from the vehicle.

9 Remove the four bolts which secure the crossmember to the frame.

10 Unplug the electrical connectors from the oxygen sensors, back-up light switch (see Section 3) and the speed sensor (see Chapter 6).

11 Unbolt the clutch release cylinder and tie it out of the way.

12 Remove the exhaust pipe/catalytic converter assembly.

13 Remove the starter (refer to Chapter 5).

14 Where fitted, remove the engine-to-transmission braces.

15 Remove the flywheel cover from the lower clutch housing.

16 Lower the rear of the transmission.

17 Disconnect the wiring harness where it is secured to the transmission in several places.

18 Disconnect the shift rod from the transmission (refer to Section 2).

19 Prise the shift lever brace retainer loose. Disconnect the shift lever brace from the transmission.

20 Support the engine assembly with a floor jack (place a block of wood on the jack head to protect the sump). The transmission should already be held with another floor jack - preferably one equipped with a transmission holding fixture.

21 Remove the transmission-to-engine bolts. Pull the transmission to the rear and separate it from the engine. Lower the transmission on the jack and wheel it out from under the vehicle.

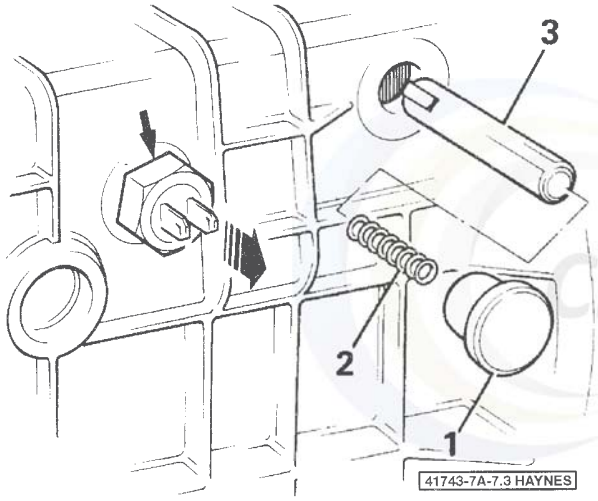
Caution: *Do not allow the transmission to tilt or hang from the input shaft. This will damage the clutch and the input shaft.*

REFITTING

Note: While the transmission is removed, it is a good idea to check the clutch for wear. Refer to Chapter 8. Or, if the vehicle has done significant miles, it may be worthwhile to replace the clutch assembly while the transmission is out of the vehicle.

22 Wheel the transmission into position on a jack, raise it up and, with the aid of a helper, carefully move it forward and guide the input shaft into the clutch disc hub and spigot bush. Make sure the input shaft is fully seated into the spigot bush. You'll know if it isn't, because the transmission case won't seat flat against the engine. If you have trouble inserting the input shaft through the clutch hub or seating it into the spigot bush, carefully wiggle the transmission. You may even have to rotate the engine or input shaft slightly to align the splines on the input shaft with the splines on the inside of the clutch hub. But do NOT try to force the input shaft through the clutch hub and into the spigot bush, or you will damage something.

23 Refit the transmission-to-engine bolts and tighten them to the torque listed in this Chapter's Specifications.



7.3 Selector rod plunger (3), spring (2) and cap (1) and backup light switch (arrow) details

24 The remainder of refitting is the reverse of removal. Make certain to align the driveshaft rear flange, the driveshaft centre support assembly and the rear crossmember using the marks you made previously. Be sure to renew the discarded locknuts from the rear of the driveshaft with new lock-nuts.

6 Transmission overhaul - general information

If your transmission reaches the end of its service life, you can save a great deal of money by removing and refitting it yourself, but you're better off leaving the overhaul to a transmission repair shop. Better yet, buy a rebuilt unit from an auto parts store or transmission repair shop. Rebuilding a manual transmission is a difficult job involving the disassembly and reassembly of many parts. The cost in time and money to overhaul a transmission yourself will almost surely exceed the cost of a rebuilt unit.

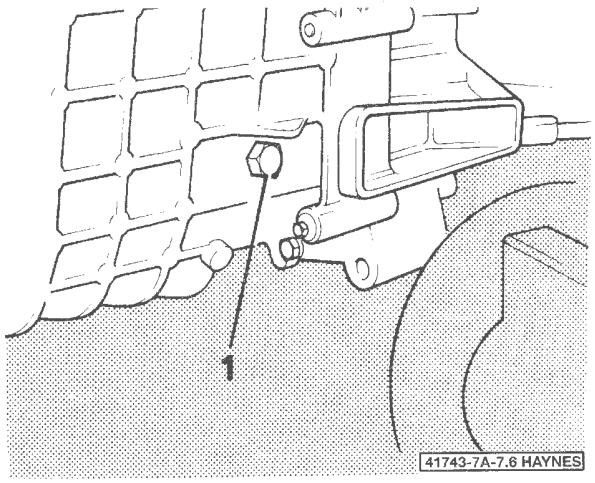
Note: Do to the complexity and special tools needed specifically for the Borg-Warner (Tremac) T56 six-speed and the Aisin D173 six speed manual transmission no overhaul information is given.

Nevertheless, it's not impossible for an inexperienced mechanic to rebuild a transmission, if the special tools are available and the job is done in a deliberate step-by-step manner so nothing is overlooked (except for the T56 six-speed and the Aisin D173 six speed manual).

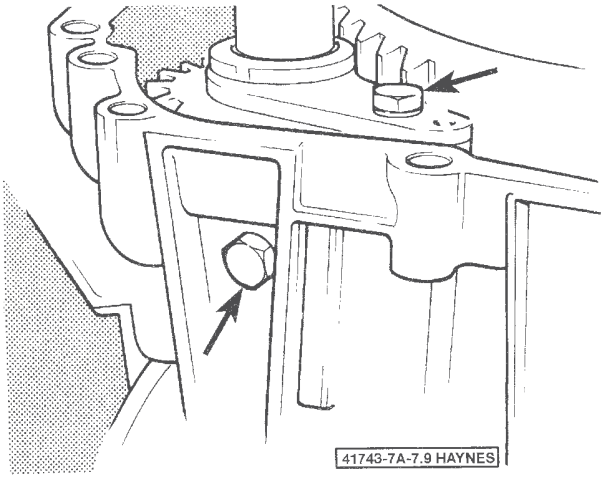
The tools needed for an overhaul include internal and external snap-ring pliers, a bearing puller, a slide hammer, a set of pin punches, a dial indicator and a hydraulic press. You will also need a large, sturdy workbench and a vice or transmission stand.

During dismantling of the transmission, make careful notes of how each piece comes off, where it fits in relation to other pieces and what holds it in place. When removing parts, note how they're fitted; this will make it easier to reassemble the transmission correctly.

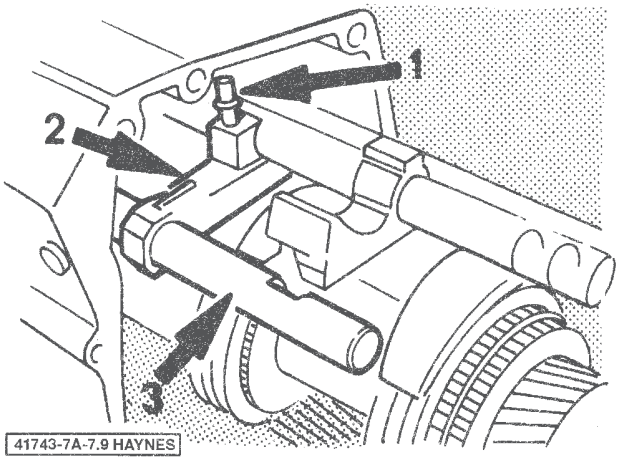
Before taking the transmission apart for repair, it will help if you have some idea what area of the transmission is malfunctioning. Certain problems can be closely tied to specific areas in the transmission, which can make component examination and renewal easier. Refer to the *Troubleshooting* Section at the front of this manual for information regarding possible sources of trouble.



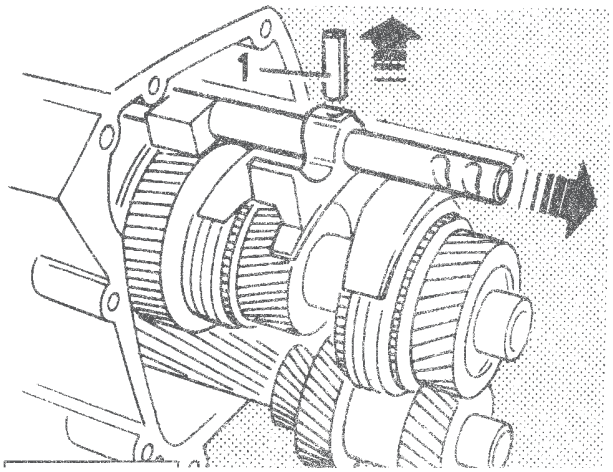
7.6 Lock bolt location (1)



7.9 Reverse idler retaining bolts (arrows)



7.11 Selector operating lever roll pin (1), operating lever (2) and selector rail (3)



7.12 Remove the roll pin (1) and withdraw the selector rod

7 Transmission overhaul

Note: Due to the complexity and special tools needed specifically for the Borg-Warner (Tremac) T56 and the Aisin D173 six-speed manual transmissions, no overhaul information is given.

DISASSEMBLY

Refer to illustrations 7.3, 7.6, 7.9, 7.11, 7.12, 7.13 and 7.14

1 Drain the transmission lubricant.

2 Unscrew and remove the back-up light switch and the selector arm lock pin assembly.

3 Using a pair of pliers, remove the selector rod lock plunger cap (1), spring (2) and plunger (3) (see illustration).

4 From inside the clutch housing, remove the clutch release components and unbolt and remove the guide sleeve.

5 Extract the circlip and shim from the front bearing.

6 Remove the reverse idler lock bolt from the side of the housing (see illustration).

7 Tap down the dowel pins between the main and the rear housing sections, then unscrew the connecting bolts and pull off the main housing. If the cluster gear bearing is displaced, note that the smaller diameter of it is towards the end of the shaft.

8 Release the lockplate, hold the output flange against rotation and unscrew the output flange nut. Draw off the flange using a puller, if necessary.

9 Unscrew the reverse idler bolts (see illustration).

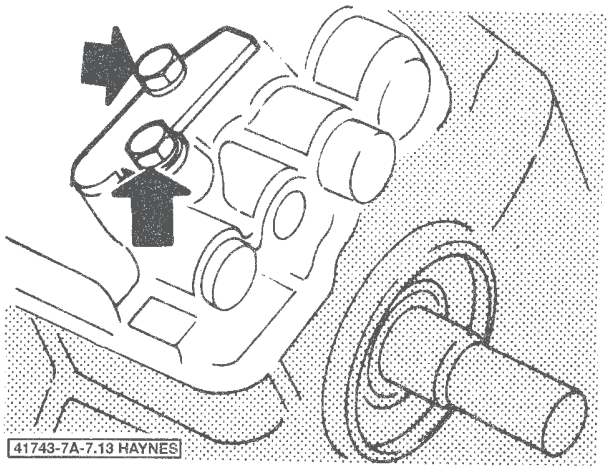
10 Remove reverse idler shaft with the gear and needle bearing.

11 Drive out the roll pin (1), pull out the selector rail (3) and take off the operating lever (2) (see illustration).

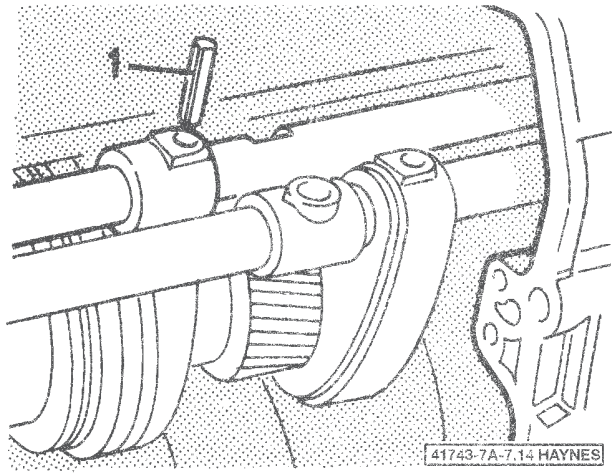
12 Move the synchro sleeve to engage 4th gear. Drive the roll pin (1) out far enough to be able to withdraw the selector rod (see illustration). Watch for the selector rod rollers.

13 Remove the detent endplate and extract the three detent springs (see illustration).

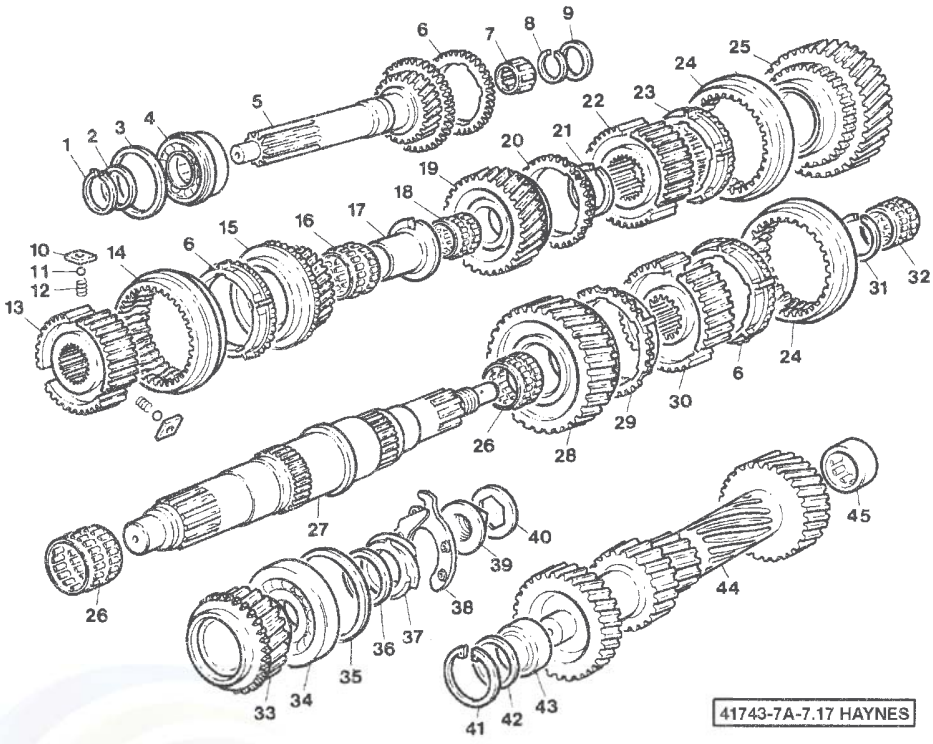
14 Drive out the roll pin from the 3rd/4th selector fork and draw the shaft out towards the front of the transmission, noting the interlock pin (see illustration).



7.13 Detent end plate securing bolts (arrows)

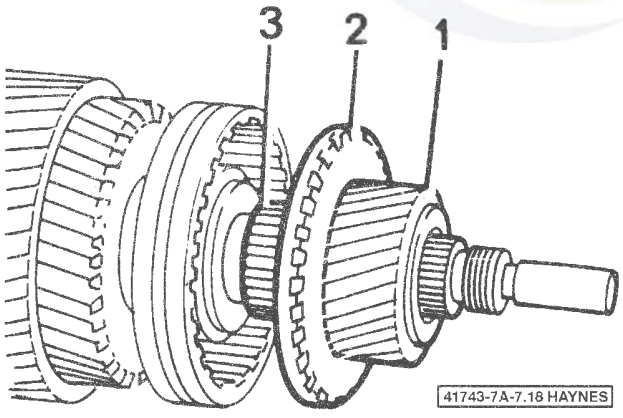


7.14 Drive out the 3rd/4th selector fork roll pin (1)



7.17 Internal transmission components - exploded view

1 *Circlip*
2 *Spacer*
3 *Spacer*
4 *Bearing*
5 *Input shaft with 4th gear*
6 *Baulk ring*
7 *Needle roller bearing*
8 *Circlip*
9 *Spacer*
10 *Sliding key*
11 *Ball*
12 *Spring*
13 *3rd/4th synchro-hub*
14 *3rd/4th synchro, sleeve*
15 *3rd gear*
16 *Needle roller bearing*
17 *Bearing sleeve*
18 *Needle roller bearing*
19 *2nd gear*
20 *Baulk ring*
21 *Circlip*
22 *1st/2nd synchro-hub*
23 *Baulk ring*
24 *1st/2nd synchro, sleeve*
25 *1st gear*
26 *Needle roller bearing*
27 *Mainshaft*
28 *Reverse gear*
29 *Baulk ring*
30 *Reverse/5th synchro-hub*
31 *Circlip*
32 *Needle roller bearing*
33 *5th gear*
34 *Bearing*
35 *Spacer*
36 *Spacer*
37 *Speed sensor*
38 *Locking lever*
39 *Nut*
40 *Nut locking cup*
41 *Circlip*
42 *Spacer*
43 *Bearing*
44 *Cluster gear*
45 *Bearing*



7.18 Remove 5th gear (1), the baulk ring (2), and needle bearing (3) from the mainshaft

15 Select 2nd gear and reverse gears together by pushing their respective selector rods towards the front of the transmission.

16 Press or tap the gear shafts simultaneously out of the rear housing section. Retrieve all the detent balls and springs.

MAINSHAFT - DISMANTLING

Refer to illustrations 7.17 and 7.18

17 Pull the input (clutch) shaft from the mainshaft, take off the baulk ring and extract the needle roller bearing (see illustration).

18 A puller or press may be needed to remove some assemblies from the shaft. Remove 5th gear (1), the baulk ring (2), and the needle bearing (3) from the rear end of the mainshaft (see illustration).

19 Extract the circlip and remove the spacer from the front end of the shaft.

20 Remove 3rd gear and the needle bearing with the 3rd/4th synchro unit.

21 Remove the bearing sleeve and 2nd gear. Take off the baulk ring and needle bearing.

22 Extract the circlip and remove 1st gear, the needle bearing and the 1st/2nd synchro unit.

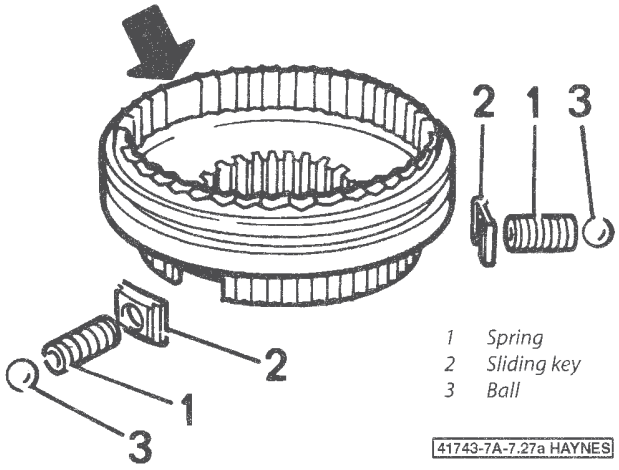
23 Extract the circlip and remove reverse gear with the synchro unit and needle bearing.

INSPECTION

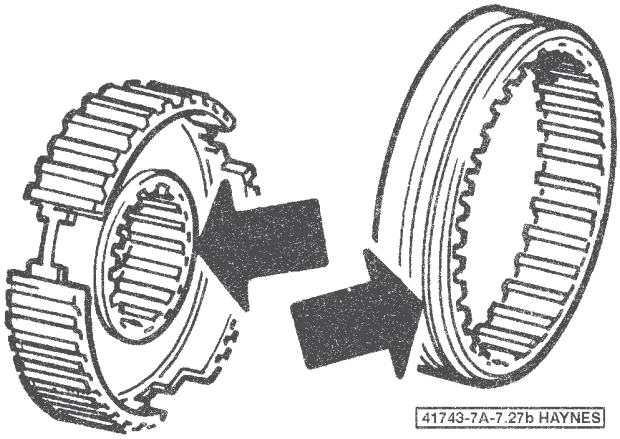
Refer to illustrations 7.27a and 7.27b

24 Renew any gears which have chipped teeth.

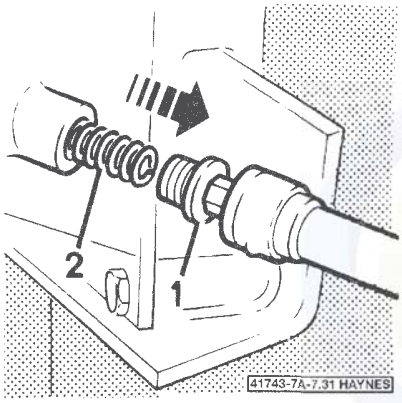
25 Check the gap between the baulk rings and the gear cones. If less than 0.8 mm, renew the baulk ring. Chipped or worn



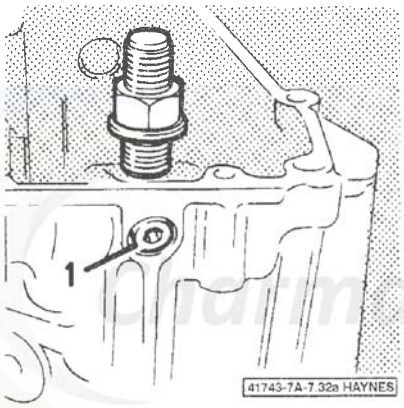
7.27a Synchro components - the flat teeth of the sleeve (arrowed) must align with the sliding keys



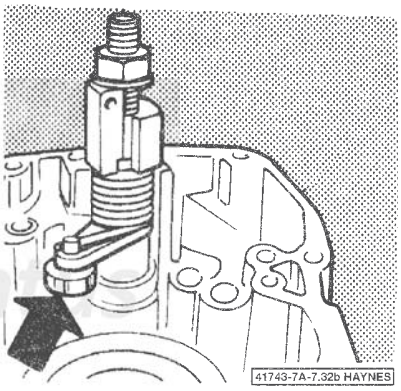
7.27b 3rd/4th synchro-hub and sleeve alignment - the groove on the sleeve must be adjacent to the smaller hub projection



7.31 The bolt (1) and spring (2) in the rear housing



7.32a Remove the socket-headed bolt (1) retaining the selector arm in the rear housing



7.32b Selector arm details - note the roller (arrow)

teeth in the synchro components will mean the purchase of new parts.

26 Pushing the hub out of the synchro sleeve will eject the springs, balls and sliding keys.

27 When reassembling, note the following points. Align the flat teeth on the sleeve with the sliding keys (see illustration). On 3rd/4th units, the groove in the sleeve must be adjacent to the smaller projection on the hub (see illustration). Make sure that the stepped side of the sliding key is towards the synchro sleeve.

28 Check the selector forks for wear and renew if worn.

BEARINGS - RENEWAL

Refer to illustrations 7.31, 7.32a, 7.32b, 7.33, 7.35a and 7.35b

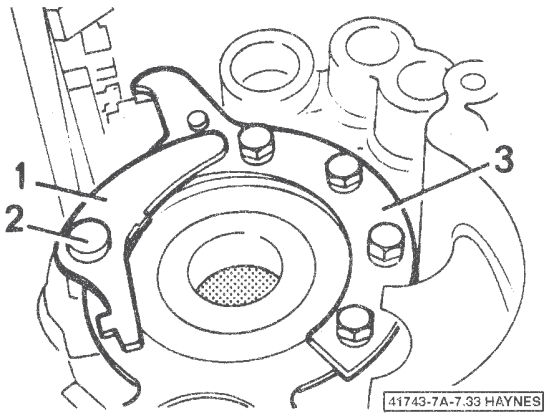
29 Wear in the shaft bearings should be rectified by renewing the bearings in the following way.

30 To remove the bearing from the main housing, extract the circlip and shim and press or draw the bearing from its seat.

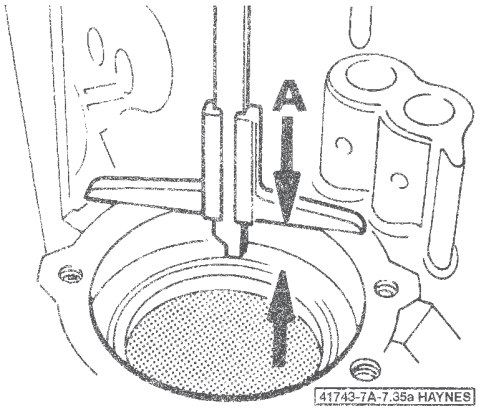
31 To remove the mainshaft bearing from the rear housing section, unscrew the bolt and remove the spring (see illustration).

32 Remove the socket-headed bolt and the selector arm (see illustrations).

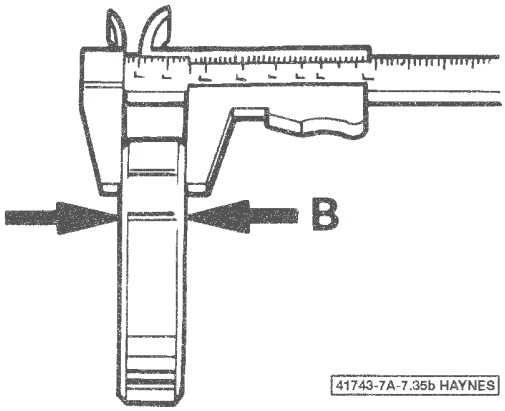
33 Unbolt and remove the bolt, locking lever spacer and bearing holder (see illustration).



7.33 Unbolt and remove the locking lever (1), the spacer (2) and the bearing holder (3)



7.35a Measure the bearing recess depth (A)



7.35b Measure the width of the new bearing (B)

34 Extract the oil seal, bearing and shim.

35 To select the shim for use with the new bearing, measure dimension (A), then the width of the new bearing (B) (see illustrations). Subtract B from A, the difference is the thickness of the required shim.

36 When fitting the bearing, heat the housing to 80-degrees C, place the selected shim in the bearing seat and press in the bearing so that its sealed face enters first.

37 Refit the bearing holder and selector arm.

CLUSTER GEAR

38 The gears cannot be removed from the cluster gear, but to renew the bearing in the rear housing section, drive out the outer track from the housing and draw the inner race from the end of the cluster gear. Fit the new bearing by reversing the removal operations, align the slot in the track with the housing lock bead.

39 To renew the cluster gear bearing in the main housing, remove the outer track and press in the new one, using the original spacer, making sure that the oil groove in the track aligns with the one in the housing. Remove the bearing race from the end of the cluster gear.

40 The cluster gear endfloat must now be checked. To do this, locate the cluster gear in the rear housing bearing track.

41 Lower the main housing into position and locate it with two dowel pins and two bolts. Unscrew the oil filler/level plug.

42 Apply the stylus of a dial gauge to the end of the cluster gear, then move the shaft up and down by inserting a screwdriver through the oil filler hole. If the endfloat is not between 0.13 and 0.23 mm (0.005 and 0.009 in), remove the bearing outer track from the main housing and change the shim for one of different thickness.

MAINSHAFT REASSEMBLY

43 Starting from the rear of the mainshaft, refit the reverse gear, the baulk ring and 5th/reverse synchro unit.

44 Fit the needle bearing, 1st gear and the baulk ring to the front end of the shaft.

45 Fit the 1st/2nd synchro. Push the sleeve towards 1st gear and fit the thickest circlip available which will eliminate all endfloat.

46 Fit the needle bearing, the baulk ring and 2nd gear.

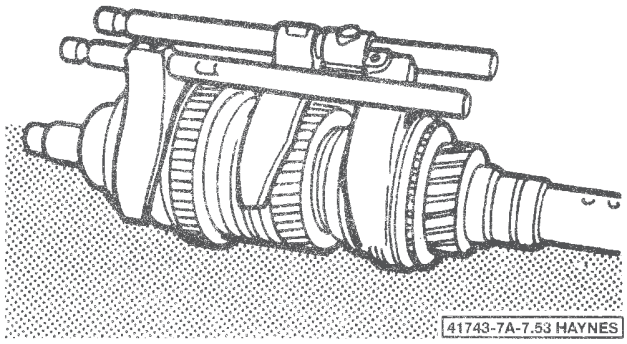
47 Heat the bearing sleeve in boiling water and fit it to the shaft.

48 Fit the needle bearing, 3rd gear and the baulk ring.

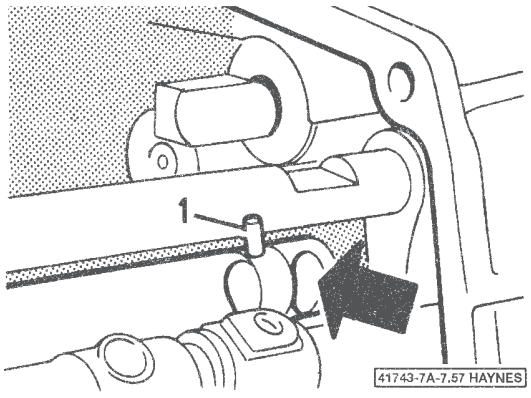
49 Fit 3rd/4th synchro unit so that the narrow groove is towards 4th gear.

50 Fit the spacer and the circlip to the front end of the mainshaft.

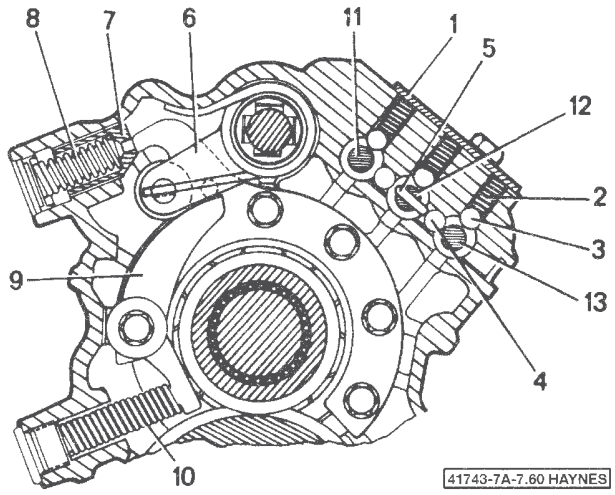
51 To the rear end of the mainshaft, fit 5th gear, the needle bearing and the baulk ring.



7.53 The 1st/2nd and 5th/reverse selector shafts and forks must be located in their mainshaft synchro sleeve grooves



7.57 3rd/4th selector shaft interlock pin (1) details



7.60 Typical detent and lock pin arrangement - Getrag 240 (Sec 7)

1 *Cover plate*
2 *Detent spring*
3 *Detent ball*
4 *Interlock ball*
5 *Interlock pin*
6 *Selector arm*
7 *Selector arm, lock pin and plug*
8 *Spring*
9 *Locking lever*
10 *Locking lever spring, plunger and cap*
11 *Reverse/5th selector shaft*
12 *3rd/4th selector shaft*
13 *1st/2nd selector shaft*

52 Insert the needle roller bearing into the recess in the input (clutch) shaft and connect it to the front end of the mainshaft.

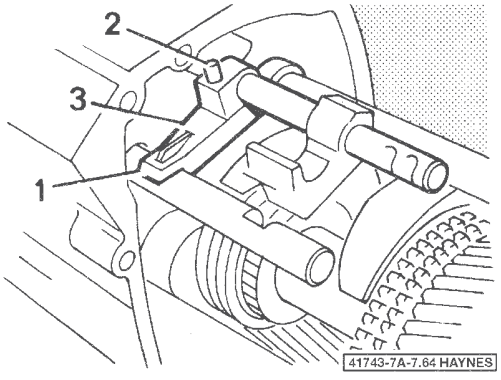
FINAL REASSEMBLY

Refer to illustrations 7.53, 7.57, 7.60, 7.62, 7.64, 7.66, 7.68a and 7.68b

53 Locate the 1st/2nd and 5th/reverse selector shafts with all the selector forks in their mainshaft synchro sleeve grooves (see illustration).

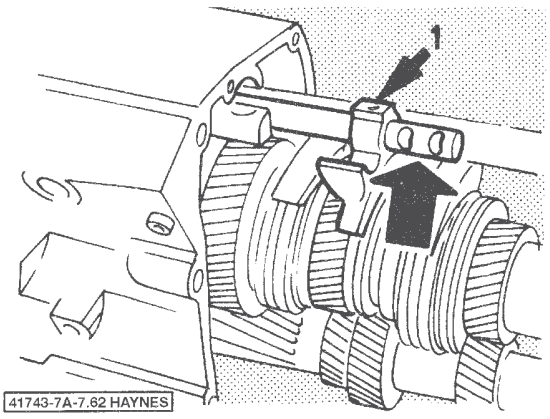
54 Make sure that all detent balls, springs and interlock pins have been removed from the rear housing.

55 Select 2nd and reverse gears simultaneously and insert the gear trains with the selector shafts all meshed together into the rear housing section.



7.64 Fitting the selector rail

1 *Groove*
2 *Roll pin*
3 *Operating lever*



7.62 Fit the selector arm to the selector shaft with a roll pin (1) - the grooves in the shaft (arrow) must face outwards

56 Move the selector shafts to set the gears in neutral.

57 Slide 3rd/4th selector shaft through the selector fork, then stick the interlock pin in the shaft with thick grease. Note the position of the detent groove (see illustration).

58 Insert the two detent balls, holding them with a blob of thick grease, and push the selector shaft into position.

59 Pin the fork to 3rd/4th selector shaft.

60 Fit the three remaining detent balls and springs, the selector arm lock pin and locking lever plunger assemblies (see illustration).

61 Fit the detent plate using thread locking fluid on the bolt threads.

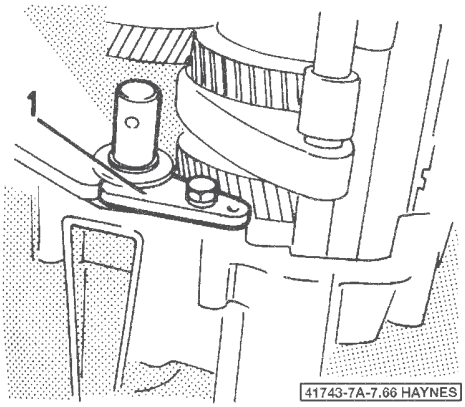
62 Drive the pin from the selector arm and locate the four rollers in position with grease. Slide in the selector shaft while at the same time fitting the selector arm and a new roll pin (see illustration).

63 Fit a new selector shaft oil seal.

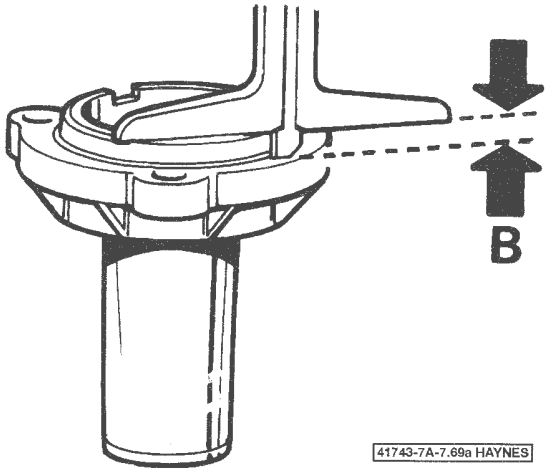
64 Fit the selector rod so that its groove is as arrowed (see illustration).

65 Apply thread locking fluid to the reverse idler shaft rear end and fit the shaft with the needle bearing and reverse gear. Apply thread locking fluid to the lock bolt and screw it into position.

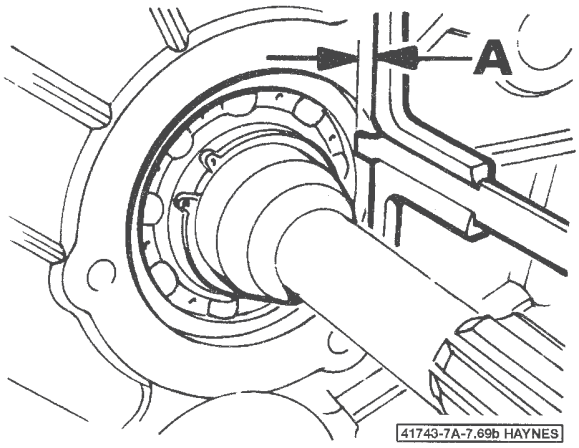
66 Fit the holder (see illustration).



7.66 Holder (1) refitting details



7.68a Measure the guide sleeve shoulder (B)



7.68b Measure the depth of the bearing (A) to determine the clearance between the front bearing and the circlip

67 Fit the output flange. Apply thread locking fluid and tighten the nut to the specified torque. Fit and stake a new lockplate.

68 Before bolting on the guide sleeve, measure the height (B) of its shoulder and of the bearing depth (A) (see illustrations). Subtract B from A and the difference will be equal to the thickness of the shim required. If there is, select a suitable circlip. Bolt on the guide sleeve with new oil seal and gasket.

69 Fit the clutch release components (Chapter 5).

70 Fit the selector arm and the selector rod lock plunger assemblies.

Chapter 7
Transmission

Part B Automatic transmission

Contents

Specifications

Torque specifications	Nm
Transmission-to-engine bolts	
3.8 litre V6 models	50 to 60
3.6 litre V6 models	52 to 66
5.0 litre V8 models	30 to 45
5.7 litre Gen III and 6.0 litre Gen IV V8 models	50 to 60
Transmission mount-to-transmission bolts	50 to 65
Transmission mount-to-crossmember nuts	20 to 30
Torque converter-to-driveplate bolts	60 to 70
Torque converter cover bolts	
3.8 litre V6 and 5.0 litre V8 models	3 to 5
3.6 litre V6 models	12 to 16
5.7 litre Gen III and 6.0 litre Gen IV models	5 to 10
Sump bolts	12

1 General information

All vehicles covered in this manual come equipped with a five-speed, or six-speed manual transmission or a four-speed or five-speed electronic automatic transmission. All information on the automatic transmission is included in this Part of Chapter 7. Information on the manual transmission can be found in Part A of this Chapter. You'll also find a procedure common to both automatic and manual transmissions - transmission mount removal and refitting - here in Part B.

VT to VY models and the VZ 175-kW 3.6 litre V6 use the same 4L60-E Hydra-matic four-speed unit. The 4L60-E is equipped with a lock-up torque converter that engages in high gear. The lock-up torque converter provides a direct connection between the engine and the drive wheels for improved efficiency and economy. The lock-up converter consists of a solenoid-controlled clutch on the torque converter that engages to lock up the converter in high gear.

Due to the high torque demands of the VZ V8 models, the 4-speed 4L65-E four speed automatic transmission is used. This is basically the same as the 4L60-E unit, except it has stronger components and is calibrated differently to the 4L60-E transmission.

The 5L40-E automatic transmission is fitted to the high output (190 kW) 3.6 litre V6 engine fitted to VZ models. This transmission is five-speed electronically controlled transmission consisting of a four-element torque converter, electronically controlled hydraulic shift solenoids, a single planetary gear set along with friction and mechanical clutches.

Due to the complexity of the automatic transmissions covered in this manual and the need for specialised equipment to perform most service operations, this Chapter contains only general diagnosis, routine maintenance, adjustment and removal and refitting procedures.

If the transmission requires major repair work, it should be left to a dealer service department or an automotive or transmission repair shop. You can, however, remove and refit the transmission yourself and save the expense, even if the repair work is done by a transmission shop.

2 Diagnosis - general

Note: Automatic transmission malfunctions may be caused by five general conditions: poor engine performance, improper adjustments, hydraulic malfunctions, mechanical malfunctions or malfunctions in the computer or its signal network. Diagnosis of these problems should always begin with a check of the easily repaired items: fluid level and condition (see Chapter 1) and shift linkage adjustment. Next, perform a road test to determine if the problem has been corrected or if more diagnosis is necessary. If the problem persists after the preliminary tests and corrections are completed, additional diagnosis should be done by a dealer service department or transmission repair shop. Refer to the Troubleshooting *Section at the front of this manual for information on symptoms of transmission problems.*

PRELIMINARY CHECKS

1 Drive the vehicle to warm the transmission to normal operating temperature.

2 Check the fluid level as described in Chapter 1:

a) If the fluid level is unusually low, add enough fluid to bring the level within the designated area of the dipstick, then check for external leaks (see below).

b) If the fluid level is abnormally high, drain off the excess, then check the drained fluid for contamination by coolant. The presence of engine coolant in the automatic transmission fluid indicates that a failure has occurred in the internal radiator walls that separate the coolant from the transmission fluid (see Chapter 3).

c) If the fluid is foaming, drain it and refill the transmission, then check for coolant in the fluid or a high fluid level.

3 Check the engine idle speed.

Note: If the engine is malfunctioning, do not proceed with the preliminary checks until it has been repaired and runs normally.

FLUID LEAK DIAGNOSIS

4 Most fluid leaks are easy to locate visually. Repair usually consists of renewing a seal or gasket. If a leak is difficult to find, the following procedure may help.

5 Identify the fluid. Make sure it's transmission fluid and not engine oil or brake fluid (automatic transmission fluid is a deep red colour).

6 Try to pinpoint the source of the leak. Drive the vehicle several miles, then park it over a large sheet of cardboard. After a minute or two, you should be able to locate the leak by determining the source of the fluid dripping onto the cardboard.

7 Make a careful visual inspection of the suspected component and the area immediately around it. Pay particular attention to gasket mating surfaces. A mirror is often helpful for finding leaks in areas that are hard to see.

8 If the leak still cannot be found, clean the suspected area thoroughly with a degreaser or solvent, then dry it.

9 Drive the vehicle for several miles at normal operating temperature and varying speeds. After driving the vehicle, visually inspect the suspected component again.

10 Once the leak has been located, the cause must be determined before it can be properly repaired. If a gasket is renewed but the sealing flange is bent, the new gasket will not stop the leak. The bent flange must be straightened.

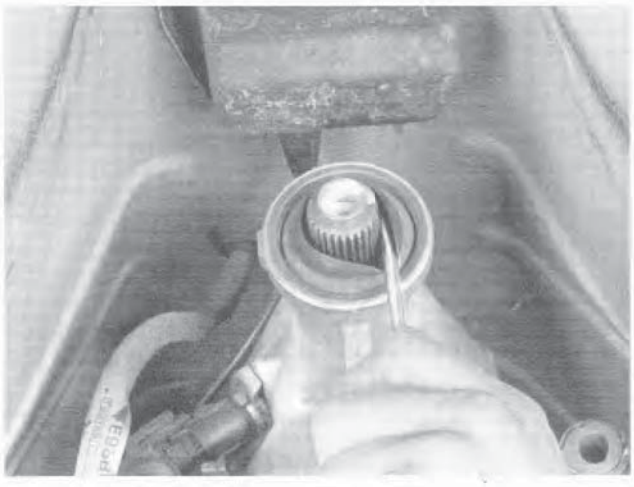
11 Before attempting to repair a leak, check to make sure that the following conditions are corrected or they may cause another leak.

Note: Some of the following conditions cannot be fixed without highly specialised tools and expertise. Such problems must be referred to a transmission repair shop or a dealer service department.

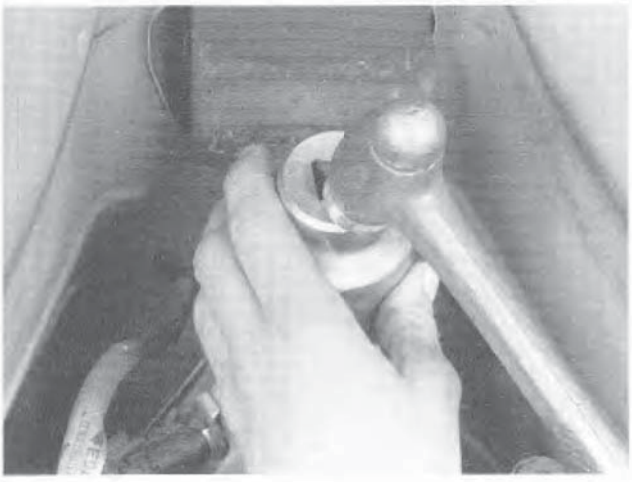
Gasket leaks

12 Check the sump periodically. Make sure the bolts are tightened to the correct torque, no bolts are missing, the gasket is in good condition and the sump is flat (dents in the sump may indicate damage to the valve body inside).

13 If the sump gasket is leaking, the fluid level may be too high, the vent may be plugged, the sump bolts may be too tight, the sump sealing flange may be warped, the sealing surface of the transmission housing may be damaged, the gasket may be damaged or the transmission casting may be cracked or porous. If sealant instead of gasket material has been used to form a seal between the sump and the transmission housing, it may be the wrong type of sealant.



3.4 Remove the extension housing seal with a large screwdriver or with a seal removal tool



3.6 Drive the new seal into the extension housing with a large socket

Seal leaks

14 If a transmission seal is leaking, the fluid level may be too high, the vent may be plugged, the seal bore may be damaged, the seal itself may be damaged or improperly refitted, the surface of the shaft protruding through the seal may be damaged or a loose bearing may be causing excessive shaft movement.

15 Make sure the dipstick tube seal is in good condition and the tube is properly seated. Periodically check the area around the speedometer gear or sensor for leakage. If transmission fluid is evident, check the O-ring for damage.

Case leaks

16 If the case itself appears to be leaking, the casting is porous and will have to be repaired or renewed.

17 Make sure the oil cooler hose fittings are tight and in good condition.

Fluid comes out vent pipe or fill tube

18 If this condition occurs, the transmission is overfilled, there is coolant in the fluid, the case is porous, the dipstick is incorrect, the vent is plugged or the drain-back holes are plugged.

3 Oil seal renewal

1 Oil leaks frequently occur due to wear of the extension housing oil seal, and/or the vehicle speed sensor oil seal and O-ring. Renewal of these seals is relatively easy, since the repairs can usually be performed without removing the transmission from the vehicle.

EXTENSION HOUSING OIL SEAL

Refer to illustrations 3.4 and 3.6

2 The extension housing oil seal is located at the extreme rear of the transmission, where the driveshaft is attached. If leakage at the seal is suspected, raise the vehicle and support it securely on jackstands. If the seal is leaking, transmission fluid will be built up on the front of the driveshaft and may be dripping from the rear of the transmission.

3 Refer to Chapter 8 and remove the driveshaft.

4 Using a screwdriver, seal removal tool or a chisel and hammer, carefully prise the oil seal out of the rear of the transmission (see illustration). Do not damage the splines on the transmission output shaft.

5 If the oil seal cannot be removed with a chisel, a special oil seal removal tool (available at auto parts stores) will be required.

6 Using a large section of pipe or a very large deep socket as a drift, fit the new oil seal (see illustration). Drive it into the bore squarely and make sure it's completely seated.

7 Lubricate the splines of the transmission output shaft and the outside of the driveshaft sleeve yoke with lightweight grease, then refit the driveshaft. Be careful not to damage the lip of the new seal.

SPEED SENSOR O-RING

Note: *Any time the speed sensor is removed, you MUST fit a new O-ring.*

8 The speed sensor is located on the right (driver's) side of the extension housing. To determine if the O-ring is leaking, look for transmission fluid around the sensor.

9 Unplug the sensor electrical connector.

10 Remove the sensor hold-down bolt and remove the sensor.

11 Remove the old O-ring and fit a new O-ring on the sensor.

12 Refitting is the reverse of removal. Tighten the sensor hold-down bolt securely.

4 Neutral start/back-up light switch - check, renewal and adjustment

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

CHECK

1 The Neutral start/back-up light switch prevents the starter motor from operating when the automatic transmission is in gear by opening the starter motor circuit. When the shift lever is put into Reverse with the engine running, the switch closes the back-up light circuit and turns on the back-up lights.

2 To check the Neutral start function of the switch, verify that the engine will start only in Neutral. If the engine starts with the transmission in gear, verify that the switch is properly adjusted (see below). If the switch still fails to work properly after it's been adjusted, it's bad. Renew it.

3 To check the back-up light function of the switch, place the shift lever in Reverse with the ignition key On. The back-up lights should come on.

4 If the back-up lights don't come on, either a fuse is blown, the bulbs are burned out, there's an open in the circuit, or the back-up light switch is bad.

5 Always begin any electrical troubleshooting procedure by checking the fuses (see Chapter 12). If a fuse is blown, renew it. If it blows again, find out why.

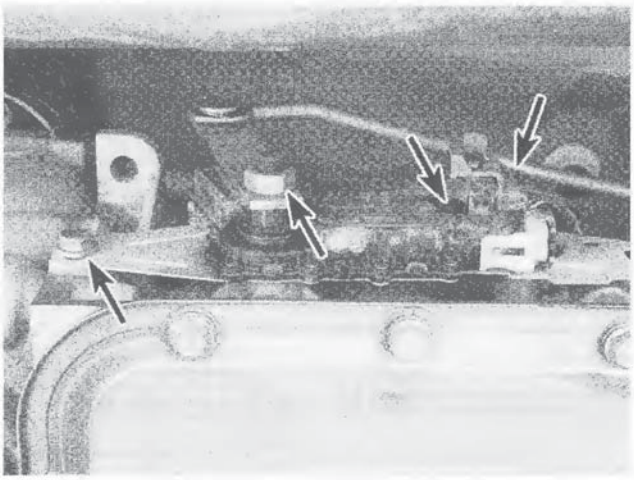
6 Check the bulbs for the back-up light circuit. If either bulb is bad, renew it (see Chapter 12). If the bulbs are good, check the circuit. Using a voltmeter, verify that voltage is getting to the switch and that, when the shift lever is placed in Reverse, there is voltage to the bulb. If the bulbs are okay and the circuit is okay, check the continuity of the switch.

RENEWAL

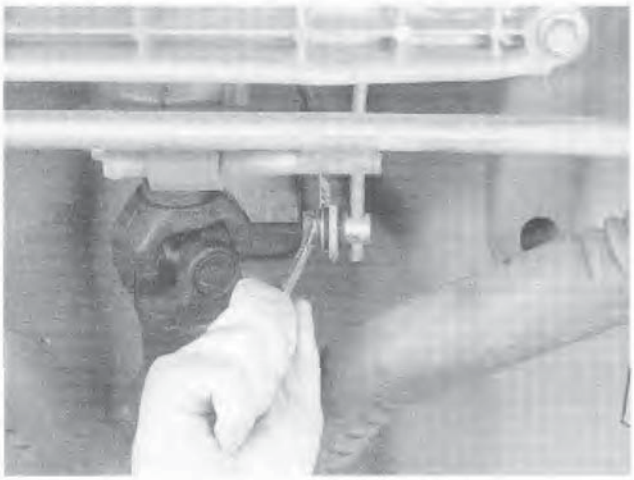
Refer to illustration 4.9

7 Disconnect the cable from the negative battery terminal.

8 Remove the gearshift lever from the manual shaft and secure it aside.



4.9 Remove the shifter nut, unplug the electrical connector, remove the bolts (arrows) and remove the Neutral start/back-up light switch



5.5 Disconnect the shift rod from the transmission lever. It must be adjusted to ensure that the neutral start switch operates correctly

9 Unplug the electrical connector from the Neutral start/back-up light switch. It will be necessary to first remove the safety retaining pin from the connector (see illustration).
10 Remove the switch retaining screws and remove the switch.
11 Be sure to adjust the switch (see below) before tightening the switch retaining screws. Refitting is otherwise the reverse of removal. Enable the airbag system (see Chapter 12).

ADJUSTMENT

12 From inside the vehicle, select REVERSE with the gearshift lever.
13 Turn the ignition ON. Have an assistant observe the back-up lights from the rear of the vehicle.
14 Rotate the switch until the best position is obtained for operation of the back-up lights.
15 Operate the gearshift lever from inside the vehicle while your assistant verifies that the back-up lights only operate when the vehicle is in REVERSE.
16 Verify that the vehicle will only start when the gearshift lever is in PARK or NEUTRAL.

5 Shift lever - removal and refitting

Refer to illustration 5.5

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

1 Disconnect the cable from the negative battery terminal. Disable the airbag system (see Chapter 12).
2 Remove the centre console (see Chapter 11).
3 Raise the vehicle and support it securely on jackstands.
4 Disconnect the wiring harness from the base of the lever.
5 Working under the vehicle, disconnect the shifter rod from the lever (see illustration).
6 Remove the nuts that retain the gearshift lever assembly to the body of the vehicle.
7 Remove the shift lever assembly.
8 Refitting is the reverse of removal. Make certain that the shift control rod under the vehicle is adjusted so that the vehicle will only start when the selector is in PARK or NEUTRAL.
9 Enable the airbag system (see Chapter 12).

6 Transmission mount - check and renewal

Refer to illustration 6.3

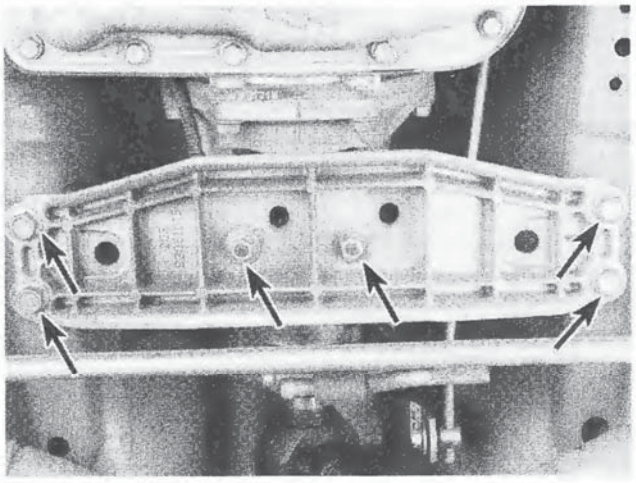
1 Raise the vehicle and place it securely on jackstands.
2 Place a lever or large screwdriver between the crossmember and the transmission and try to prise the transmission up and down. If the mount is cracked or torn, renew it.
3 Unbolt the mount from the crossmember and from the transmission (see illustration).
4 Support the transmission with a floor jack and raise the transmission until the mount studs are clear of the crossmember, then remove the mount.
5 Refitting is the reverse of removal.

7 Automatic transmission - removal and refitting

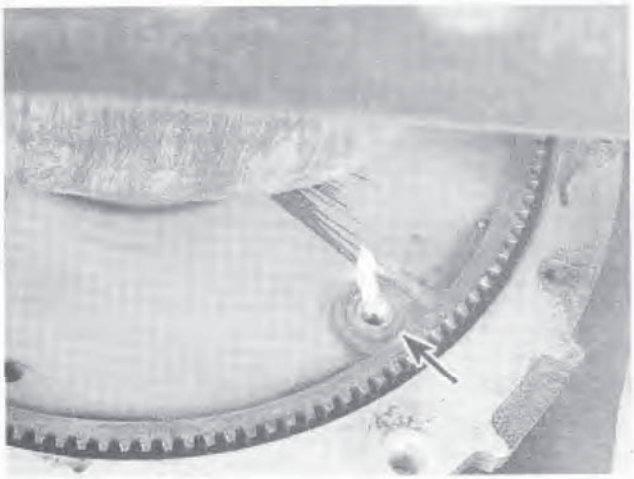
REMOVAL

Refer to illustration 7.12

1 Disconnect the cable from the negative battery terminal.
2 Remove the oil fill tube from the transmission. Plug the hole.
3 Raise the vehicle and place it securely on jackstands.



6.3 To remove the transmission mount, support the transmission and remove the fasteners from the crossmember and the rear of the transmission



7.12 Mark the relationship of the torque converter to the driveplate, then rotate the crankshaft pulley to reach each flywheel-to-torque converter bolt

4 Drain the transmission fluid (see Chapter 1).
5 Disconnect the selector link at the transmission.
6 Remove the driveshaft (see Chapter 8).

***Note:** There are important procedures for the removal of the driveshaft which must be followed carefully to avoid vibration problems.*

7 Clearly label, then unplug, all electrical connectors.
8 Where necessary, remove the exhaust pipe/catalytic converter assembly.
9 Remove the starter (refer to Chapter 5).
10 On V6 models, remove the two transmission-to-engine support (beaming) braces.
11 Remove the screws from the torque converter access cover. Remove the cover.
12 Mark the relationship of the torque converter and driveplate with white paint so they can be refitted in the same position (see illustration).
13 Remove the flywheel-to-torque converter bolts. Turn the crankshaft for access to each bolt. Turn the crankshaft in a clockwise direction only (as viewed from the front). These bolts should be renewed when refitting the transmission.
14 Use paint or a scribe to mark the exact position of each end of the rear transmission crossmember where it contacts the frame.

***Caution:** If this is not done, there is a high probability of vibration and/or handling problems after assembly. Remove the transmission-to-crossmember bolts.*

15 Support the rear of the transmission with a floor jack, taking its weight off of the rear mount.

***Note:** Use a block of wood on the jack to avoid damaging the transmission.*

16 Remove the bolts which secure the crossmember to the frame. Remove the crossmember.
17 Lower the rear of the transmission.
18 Disconnect the wiring harness from the transmission.

***Caution:** Do not wiggle the harness connector while disconnecting it. This can damage it. Pull back the rubber seal, then squeeze the wide part of the connector and pull it straight apart.*

19 Disconnect the oil cooler lines from the transmission.
20 Disconnect the wiring harness from the neutral-start switch (refer to Section 4).
21 Remove the converter housing-to-engine bolts.
22 Support the engine with a padded jack from below.
23 Pull the transmission to the rear, separate it from the engine and lower it slightly.
24 Clamp a pair of locking pliers onto the lower portion of the transmission case, just in front of the torque converter. The pliers will prevent the torque converter from falling out while you're removing the transmission. Move the transmission to the rear to disengage it from the engine block dowel pins and make sure the torque converter is detached from the driveplate. Lower the transmission on the jack and wheel it out from under the vehicle.

REFITTING

25 Make sure the torque converter hub is securely engaged with the pump. If you've removed the converter, spread transmission fluid on the torque converter rear hub, where the transmission front seal rides. With the front of the transmission facing up, rotate the converter back and forth. It should drop down into the transmission front pump in stages. To ensure that the converter is fully engaged, lay a straightedge across the transmission-to-engine mating surface and make sure the converter hub is at least 15 mm below the straightedge. Reinstall the locking pliers to hold the converter in this position.
26 With the transmission secured to the jack, wheel it into position, raise it up into position and connect the oil cooler lines.
27 Turn the torque converter to line up the holes with the holes in the driveplate. The white paint mark made on the torque converter and driveplate in Step 12 must line up.

28 With the aid of a helper, carefully move the transmission forward until the dowel pins and the torque converter are engaged. Make sure the transmission mates with the engine with no gap. If there's a gap, make sure there are no wires or other objects pinched between the engine and transmission, and also make sure the torque converter is completely engaged in the transmission front pump. Try to rotate the converter - if it doesn't rotate easily, it's probably not fully engaged in the pump. If necessary, lower the transmission and refit the converter fully.

29 Refit the transmission-to-engine bolts and tighten them to the torque listed in this Chapter's Specifications. Tighten the lower bolts first, then the upper ones, finally the centre ones on each side. As you're tightening the bolts, verify that the engine and transmission mate completely at all points. If not, find out why. Never try to force the engine and transmission together with the bolts or you'll break the transmission case.

30 Fit new torque converter-to-driveplate bolts. Tighten them to the torque listed in this Chapter's Specifications.

31 Refit the transmission mount and crossmember. Tighten all nuts and bolts securely. Refer to Chapter 2 for the correct refitting of the V6 beaming braces.

32 Remove the jackstands supporting the engine and transmission.

33 Refit the dipstick tube.

34 Reconnect all electrical connectors.

35 Reconnect the driveshaft (see Chapter 8).

36 Check and refill the transmission with the specified fluid (see Chapter 1).

37 Remove the jackstands and lower the vehicle.

Chapter 8
Clutch and driveline

Contents

Specifications

General

Clutch disc lining thickness	
3.8 litre V6 and 5.0 litre V8 models	0.5 mm (above rivet)
3.6 litre V6 models	8.2 to 8.6 mm with 7,000 Newton load applied
5.7 litre Gen III V8	8.40 to 9.05 mm with 10,000 Newton load applied
6.0 litre Gen IV V8	8.5 to 9.1 mm with 11,000 Newton load applied
Fluid type	
3.8 litre V6 and 5.0 litre V8 models	DOT 3 brake fluid
All other models	DOT 4 brake fluid

Torque specifications

	Nm (unless otherwise indicated)
Clutch	
Pressure plate-to-flywheel bolts	
3.8 litre V6 models	20 to 30**
5.0 litre V8 models	41 to 47
3.6 litre V6 models	25
5.7 litre Gen III V8 and 6.0 litre Gen IV V8 models	
Step 1	15
Step 2	35
Step 3	55
Step 4	70
Master cylinder mounting nuts	20 to 30
Release cylinder mounting bolts	
3.8 litre V6 and 5.0 litre V8 models	20 to 25
3.6 litre V6 models	17
5.7 litre Gen III V8 and 6.0 litre Gen IV V8 models	10
Fluid pipe fitting nuts	8 to 13

*** With clutch diaphragm spring applied using special tool*

Torque specifications (continued) **Nm**
(unless otherwise indicated)

Driveaxle

CV joint flange bolts
- Step 1 50
- Step 2
  - VT to VY models ..... Tighten an additional 60 to 75 degrees
  - VZ models ..... Tighten an additional 90 degrees

Driveshaft

Centre support bearing carrier bolts ..... 20 to 25
Centre support bearing cup guide bolts ..... 20 to 25
Differential carrier-to-crossmember bolt
- Step 1 ..... 90*
- Step 2 ..... Tighten an additional 30 to 45 degrees

Driveshaft centre constant velocity joint bolts 27
Driveshaft flexible joint bolts
- VT to VX models ..... 74 to 80
- VY models
  - Step 1 ..... 18*
  - Step 2 ..... Tighten an additional 50 to 60 degrees
- VZ models 115*

Final drive unit

Rear crossmember front bolts
- Step 1 125
- Step 2 ..... Tighten an additional 30 to 45 degrees

Rear mount-to-body bolts
- VT to VY models ..... 30 to 40*
- VZ models
  - Step 1 35
  - Step 2 ..... Tighten an additional 60 degrees

Rear mount-to-rear cover bolts ..... 85 to 105*

** New bolts must be used*

*** With clutch diaphragm spring applied using special tool*

1 General information

The information in this Chapter deals with the components from the rear of the engine to the rear wheels (except for the transmission, which is dealt with in the previous Chapter). These components are grouped into four categories: clutch, driveshaft, final drive and driveaxles. Separate Sections within this Chapter offer general descriptions and checking procedures for components in each of the four groups.

Because nearly all the procedures covered in this Chapter involve working under the vehicle, make sure that it's securely supported on sturdy jackstands or on a hoist where the vehicle can be easily raised and lowered.

2 Clutch - description and check

1 All vehicles with a manual transmission use a single dry plate, diaphragm spring type clutch. The clutch disc has a splined hub which allows it to slide along the splines of the transmission input shaft. The clutch and pressure plate are held in contact by spring pressure exerted by the diaphragm in the pressure plate.

2 Hydraulic operation is standard on all models. The hydraulic system is operated through the pedal, a master cylinder, a fluid line and a release cylinder. Depending on the model, the release cylinder can surround the input shaft of the transmission acting directly on the pressure plate, or via an actuating lever operating against the release bearing.

3 When force is applied to the clutch pedal to release the clutch, force is exerted against the outer end of the clutch release lever, on 3.8 litre V6 and 5.0 litre V8 models, or directly onto the release bearing on other models. On 3.8 litre V6 and 5.0 litre V8 models, as the lever pivots, the shaft fingers push against the release bearing. The bearing pushes against the fingers of the diaphragm spring of the pressure plate assembly, which in turn releases the clutch plate.

4 Terminology can be a problem when discussing the clutch components because common names are in some cases different from those used by the manufacturer. For example, the driven plate is also called the clutch plate or disc, the clutch release bearing is sometimes called a throwout bearing, the spigot bush is sometimes called the pilot bearing.

5 Other than to renew components with obvious damage, some preliminary checks should be performed to diagnose clutch problems.

a) The first check should be of the hydraulic system. Inspect all components for signs of fluid leakage. Make sure to check the firewall inside the vehicle as well. Check the fluid level in the clutch fluid reservoir.

b) To check "clutch spin-down time," run the engine at normal idle speed with the transmission in Neutral (clutch pedal up - engaged). Disengage the clutch (pedal down), wait several seconds and shift the transmission into Reverse. No grinding noise should be heard. A grinding noise would most likely indicate a problem in the pressure plate or the clutch disc.

c) To check for complete clutch release, run the engine (with the parking brake applied to prevent movement) and hold the clutch pedal approximately 12 mm from the floor. Shift the transmission between First gear and Reverse several times. If the shift is hard or the transmission grinds, component failure is indicated.

d) Visually inspect the pivot bush at the top of the clutch pedal to make sure there is no binding or excessive play.

e) Crawl under the vehicle and make sure the clutch release lever is solidly mounted on the ball stud.

3 Clutch pedal - removal and refitting

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

1 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the cover from the lower right side of the instrument panel (refer to Chapter 11). Pull down on the upper part of the cover to release it, then slide out the lower left hinge pin.

3 Remove the two clips securing the instrument panel lower inside cover. Remove the bulb holder by twisting it.

4 Where necessary, remove the screws securing the body control module panel (refer to Chapter 11). It is not necessary to remove the data link connector or other components. Move the panel aside and secure it with tape or wire.

5 Remove the clutch pushrod retaining clip and its washer. Or, on VZ models, prise the pushrod from the lever with a screwdriver.

***Note:** On VZ models, the retaining clip is integral with the pushrod. Prise it by levering between the side of the pedal and the pushrod.*

6 Make a note of the position of the clutch return spring. It must be refitted in this same position. Disconnect the return spring from the pedal.

7 Remove the pedal pivot bolt and remove the pedal.

8 Refitting is the reverse of removal. Lubricate all wear surfaces with molybdenum disulphide grease.

9 Refer to Chapter 12 and enable the SRS system.

4 Clutch master cylinder - removal and refitting

***Warning:** These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

***Note:** It is not recommended that clutch master cylinders of this type be rebuilt. The cylinder bore cannot be honed and if the rubber components are worn enough to require renewal, the bore is likely in poor condition as well.*

1 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the cover from the lower right side of the instrument panel (refer to Chapter 11). Pull down on the upper part of the cover to release it, then slide out the lower left hinge pin.

3 Remove the two clips securing the instrument panel lower inside cover. Remove the bulb holder by twisting it.

4 Remove the eight screws securing the body control module panel. It is not necessary to remove the data link connector or other components. Move the panel aside and secure it with tape or wire.

5 Remove the clutch pushrod retaining clip and its washer. Pull the master cylinder pushrod from the pedal.

6 From under the bonnet, remove the brake master cylinder reservoir and its bracket. Tie the assembly out of the way and be careful to avoid spilling fluid.

7 Disconnect the tube from the clutch master cylinder. Plug both open ports to avoid contamination and spillage.

8 Remove the two mounting nuts, then remove the clutch master cylinder with the reservoir attached. Lift the cylinder from the vehicle carefully to avoid spilling fluid on painted surfaces.

9 Refitting is the reverse of removal. Bleed the system (refer to Section 9).

10 Refer to Chapter 12 and enable the SRS system.

5 Clutch release cylinder - removal and refitting

***Note:** It is not recommended that clutch release cylinders of this type be rebuilt. The cylinder bore cannot be honed and if the rubber components are worn enough to require renewal, the bore is likely in poor condition as well.*

1 Raise the vehicle and support it securely on jackstands.

2 Place a drain pan beneath the release cylinder.

3.8 LITRE V6 AND 5.0 LITRE V8 MODELS

3 Disconnect the hydraulic hose from the steel tube. Plug both ports to avoid spillage and contamination.

4 Remove the hose from its bracket by pulling out the hose retaining clip.

5 Hold the cylinder against the clutch housing and remove the mounting nuts. Remove the cylinder.

6 Refitting is the reverse of removal. Bleed the system (refer to Section 9).

3.6 LITRE V6 MODELS

7 Remove the transmission from the vehicle (see Chapter 7 Part A).

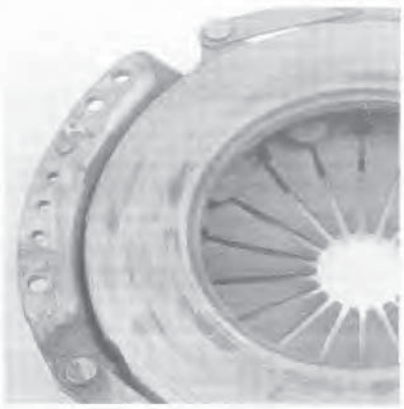
8 Remove the bolt and the wire retaining clip holding the clutch fluid pipe and adapter to the outside of the transmission housing. Slide the adapter and pipe as an assembly from the transmission housing.

9 Remove the three bolts holding the release bearing and release cylinder assembly and the single bolt holding the pipe to the inside of the transmission housing. Slide the assembly from the transmission and separate the pipe from the slave cylinder.

10 Refitting is the reverse of removal. Use new O-rings where necessary and bleed the system (refer to Section 9).

6.5 If you are not renewing the clutch, be sure to mark it to the flywheel before disassembly

6.8 This flywheel shows signs of wear - it should be resurfaced



6.14a Examine the clutch for score marks, cracks and signs of overheating

5.7 LITRE GEN III V8 AND 6.0 LITRE GEN IV V8 MODELS

11 Remove the transmission from the vehicle (see Chapter 7 Part A).

12 Disconnect the hydraulic pipe from the release cylinder.

13 Remove the two bolts holding the release cylinder assembly to the transmission adapter plate and slide the assembly from the input shaft.

14 Refitting is the reverse of removal. Bleed the system (refer to Section 9).

6 Clutch components - removal, inspection and refitting

Warning 1: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Chapter 12 for the disabling and enabling procedures.*

Warning 2: *Dust produced by clutch wear and deposited on clutch components is hazardous to your health. DO NOT blow it out with compressed air and DO NOT inhale it. DO NOT use petrol or petroleum-based solvents to remove the dust. Brake system cleaner should be used to flush the dust into a drain pan. After the clutch components are wiped clean with a rag, dispose of the contaminated rags and cleaner in a covered, marked container.*

REMOVAL

Refer to illustration 6.5

1 Access to the clutch components is normally accomplished by removing the transmission, leaving the engine in the vehicle. If, of course, the engine is being removed for major overhaul, then check the clutch for wear and renew worn components as necessary. However, the relatively low cost of the clutch components compared to the time and trouble spent gaining access to them warrants their renewal anytime the engine or transmission is removed, unless they are new or in near perfect condition. The following procedures are based on the assumption the engine will stay in place.

2 Referring to Chapter 7 Part A, remove the transmission from the vehicle. Support the engine while the transmission is out. Preferably, an engine hoist should be used to support it from above. However, if a jack is used underneath the engine, make sure a piece of wood is positioned between the jack and sump to spread the load.

Caution: *The pick-up for the oil pump is very close to the bottom of the sump. If the sump is bent or distorted in any way, engine oil starvation could occur.*

3 Where fitted, the clutch fork and release bearing can remain attached to the transmission clutch housing for the time being.

4 To support the clutch disc during removal, refit a clutch alignment tool through the clutch disc hub, if possible.

5 Carefully inspect the flywheel and pressure plate for indexing marks. If they cannot be found, make scribe marks yourself so the pressure plate and the flywheel will be in the same alignment during refitting (see illustration). If a new unit is to be fitted, ignore this step.

6 Turning each bolt only 1/4-turn at a time, loosen the pressure plate-to-flywheel bolts. Work in a crisscross pattern until all spring pressure is relieved. Then hold the pressure plate securely and remove the bolts completely, followed by the pressure plate and clutch disc.

INSPECTION

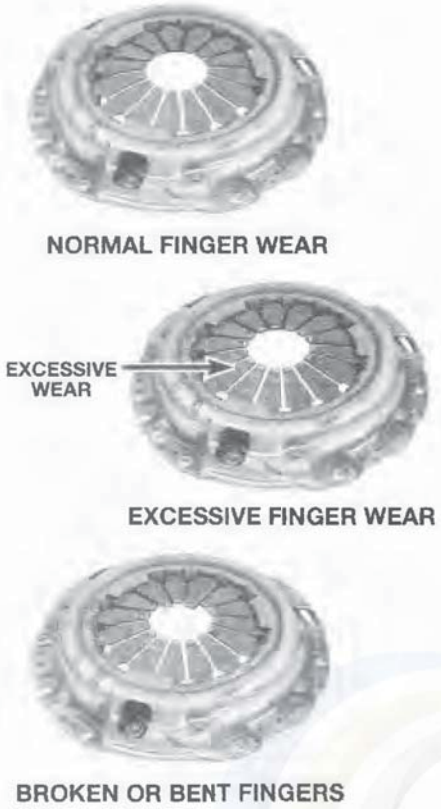
Refer to illustrations 6.8, 6.14a and 6.14b

7 Ordinarily, when a problem occurs in the clutch, it can be attributed to wear of the clutch driven plate assembly (clutch disc). However, all components should be inspected at this time.

8 Inspect the flywheel for cracks, heat checking, grooves and other obvious defects (see illustration).

9 If the V6 flywheel is damaged, it must be renewed. Because it is a dual-mass design, machining it or renewing the ring gear is not possible.

10 On V8 flywheels, if the imperfections are slight, a machine shop can machine the surface flat and smooth, which is highly



6.14b Renew the pressure plate if excessive wear is noted

recommended regardless of the surface appearance. Refer to Chapter 2 for the flywheel removal and refitting procedure.

11 Inspect the spigot bush (see Section 8).

> ***Note:*** *3.6 litre V6 models have no spigot bush or bearing.*

12 Inspect the lining on the clutch disc. Check for loose rivets, distortion, cracks, broken springs and other obvious damage. As mentioned above, ordinarily the clutch disc is routinely renewed, so if in doubt about the condition, renew it.

13 The release bearing should also be renewed along with the clutch disc (see Section 6).

14 Check the machined surfaces and the diaphragm spring fingers of the pressure plate (see illustrations). If the surface is grooved or otherwise damaged, renew the pressure plate. Also check for obvious damage, distortion, cracking, etc. Light glazing can be removed with medium grit emery cloth. If a new pressure plate is required, new and factory-rebuilt units are available.

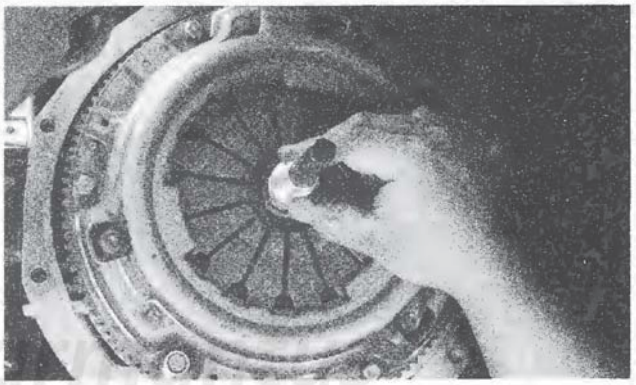
15 On 3.8 litre V6 and 5.0 litre V8 models, inspect the ball stud, the release lever and the bearing retainer on the transmission for wear and burrs. Renew any parts that require it.

REFITTING

Refer to illustration 6.17, 6.18

16 Before refitting, clean the flywheel and pressure plate machined surfaces with lacquer thinner or acetone. It's important that no oil or grease is on these surfaces or the lining of the clutch disc. Handle the parts only with clean hands. After you're done, lubricate the spigot bearing with a small amount of clean engine oil.

6.17 On 5.7 litre Gen III V8 and 6.0 litre Gen IV V8, press against the pressure plate diaphragm spring illustrated at point A, then slide the stepped adjusting ring fully counter clockwise illustrated at point B



6.18 A clutch alignment tool is necessary to fit the new disc. An old transmission input shaft works even better

17 On Gen III and Gen IV V8 models, place the clutch plate with the flat side down on a press plate, then place the pressure plate over the top of the clutch plate. Use a suitable adapter that will press evenly over each finger of the pressure plate diaphragm spring and press the fingers into the pressure plate until the clutch plate is not under spring pressure from the pressure plate. Using a screwdriver, slide the stepped adjusting ring fully anti-clockwise, compressing the small tension springs (see illustration). Once this is done, release the pressure from the pressure plate diaphragm and the pressure plate will now be locked in the released position.

> ***Note:*** *Failure to do this procedure will result in incorrectly tensioned pressure plate-to-flywheel bolts and possible damage to the clutch disc. Once the clutch is assembled and the transmission is installed, the first time the clutch pedal is depressed the pressure plate will unlock and work normally.*

18 Position the clutch disc and pressure plate against the flywheel with the clutch held in place with an alignment tool (see illustration). Make sure it's oriented properly (most clutch plates will be marked "flywheel side" or something similar - if not marked, fit the clutch disc with the damper springs toward the transmission).

19 Tighten the pressure plate-to-flywheel bolts only finger tight, working around the pressure plate.

20 Centre the clutch disc by ensuring the alignment tool extends through the splined hub and into the spigot bush in the crankshaft. Wiggle the tool up, down or side-to-side as needed to bottom the tool in the spigot bush.

21 On 3.8 litre V6 models, obtain a pressure plate loading tool, Holden #AKM-632-A or its equivalent. Press in on the handle to disengage the clutch while completing the tightening procedure.

Caution: *Failure to use this tool on V6 clutches will result in a deformed clutch pressure plate cover and incorrect bolt torques.*

Tighten the pressure plate-to-flywheel bolts a little at a time, working in a crisscross pattern to prevent distorting the cover. After all of the bolts are snug, tighten them to the torque listed in this Chapter's Specifications. Remove the alignment tool.

22 On all other models, tighten the pressure plate-to-flywheel bolts a little at a time, working in a crisscross pattern to prevent distorting the cover. After all of the bolts are snug, tighten them to the torque listed in this Chapter's Specifications. Remove the alignment tool.

23 Using high-temperature grease, lubricate the inner groove of the release bearing (see Section 7). Also place a small amount of grease on the release lever contact areas and the transmission input shaft bearing retainer.

24 Refit the clutch release bearing as described in Section 7.

25 Refit the transmission and all components removed previously. Tighten all fasteners to the proper torque specifications.

7 Clutch release bearing - removal, inspection and refitting

Warning: *Dust produced by clutch wear and deposited on clutch components is hazardous to your health. DO NOT blow it out with compressed air and DO NOT inhale it. DO NOT use petrol or petroleum-based solvents to remove the dust. Brake system cleaner should be used to flush the dust into a drain pan. After the clutch components are wiped clean with a rag, dispose of the contaminated rags and cleaner in a covered, marked container.*

REMOVAL

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the transmission (see Chapter 7A). The release bearing is inside the clutch housing.

3 On 3.8 litre V6 and 5.0 litre V8 models, remove the clutch release fork from the wire clip, then remove the release bearing from the fork.

4 On 3.6 litre V6 models, the release bearing can be pulled from the clutch release cylinder assembly. If necessary, the boot behind the bearing can be renewed. All other parts of the release cylinder assembly are supplied as an assembly only.

5 On 5.7 litre Gen III V8 and 6.0 litre Gen IV V8 models, twist and pull the bearing assembly from the sleeve.

INSPECTION

6 Hold the centre of the bearing and rotate the outer portion while applying force. If the bearing doesn't turn smoothly or if it's noisy, renew it. Wipe the bearing with a clean rag and inspect it for damage, wear and cracks. Don't immerse the bearing in solvent - it's sealed for life and to do so would ruin it. Also check the release fork and the ball stud for wear, cracks and other damage.

REFITTING

7 On 3.8 litre V6 and 5.0 litre V8 models, lightly lubricate the clutch fork fingers and the release bearing with a soap based EP high-temperature grease. Also lubricate the recess inside the bearing with the same grease. Engage the release fork and release bearing. Lubricate the ball on the pivot stud and the ball socket on the back of the release fork with high-temperature grease, then push the fork onto the pivot stud until it's firmly seated. Engage the wire retaining clip. Lightly grease the fork where it contacts the bearing.

8 On the other models, use a soap based EP high-temperature grease to lubricate the sleeve the bearing slides along.

9 Prior to refitting the transmission, apply a light coat of grease to the transmission front bearing retainer.

Note: *This step is not necessary on the 3.6 litre V6 model.*

10 The remainder of refitting is the reverse of the removal procedure.

8 Spigot bush - inspection and renewal

Refer to illustrations 8.8 and 8.9

Note: *Due to the design of the transmission and clutch, the 3.6 litre V6 model does not use a spigot bearing or bush.*

1 The clutch spigot bush is an oil-impregnated type bush which is pressed into the rear of the crankshaft. Its purpose is to support the front of the transmission input shaft. It should be inspected whenever the clutch components are removed from the engine. Due to its inaccessibility, if you are in doubt as to its condition, renew it.

Note: *If the engine has been removed from the vehicle, disregard the following steps which don't apply.*

2 Remove the transmission (refer to Chapter 7 Part A).

3 Remove the clutch components (see Section 6).

4 Inspect for any excessive wear, scoring, lack of grease, dryness or obvious damage. If any of these conditions are noted, it should be renewed. A flashlight will be helpful to direct light into the recess.

8.8 Fill the cavity behind the bush with grease ...

8.9 ... then force it out by striking the packed grease with a tight-fitting bar

5 Removal can be accomplished with a special puller or a slide hammer, but an alternative method also works well.

6 Find a solid steel bar which is slightly smaller in diameter than the bush. Alternatives to a solid bar would be a wood dowel or a socket with a bolt fixed in place to make it solid.

7 Check the bar for fit - it should just slip into the bush with very little clearance.

8 Pack the bush and the area behind it (in the crankshaft recess) with heavy grease. Pack it tightly to eliminate as much air as possible (see illustration).

9 Insert the bar into the bush bore and strike the bar sharply with a hammer, which will force the grease to the back side of the bush and push it out (see illustration). Remove the bush and clean all grease from the crankshaft recess.

10 To fit the new bush, lightly lubricate the outside surface with lithium-based grease, then drive it into the recess with a soft-face hammer. Most new bushes come already lubricated, but if it is dry, apply a thin coat of high-temperature grease to it.

11 Refit the clutch components, transmission and all other components removed previously, tightening all fasteners properly.

9 Clutch hydraulic system - bleeding

Note: *The hydraulic system must be bled whenever air has entered the system for any reason, if any hydraulic component has been renewed or if the fluid level has become too low in the reservoir.*

1 Fill the clutch master cylinder reservoir with fresh, clean brake fluid (of the recommended type).

2 Raise the vehicle and support it securely on jackstands.

3 Place a tight-fitting rubber hose over the bleeder screw on the release cylinder. Place the other end of the hose into a clean glass container partially filled with fresh brake fluid.

4 Loosen the bleeder screw approximately one half turn.

5 Slowly operate the clutch pedal by hand in full strokes to the floor and back. Repeat this until bubbles no longer appear from the end of the hose.

6 Do not allow the fluid level in the reservoir to become too low.

7 Have an assistant hold the pedal down, then tighten the bleeder screw.

8 Recheck the fluid level.

10 Driveline inspection

1 Raise the rear of the vehicle and support it securely on jackstands. Block the front wheels to keep the vehicle from rolling off the stands.

2 Crawl under the vehicle and visually inspect the driveshaft. Look for any dents or cracks in the tubing. If any are found, the driveshaft must be renewed.

3 Check for oil leakage at the front and rear of the driveshaft. Leakage where the driveshaft enters the transmission indicates a defective transmission extension housing seal (see Chapter 7). Leakage where the driveshaft enters the differential indicates a defective pinion seal (see Section 17).

4 While under the vehicle, have an assistant rotate a rear wheel so the driveshaft will rotate. As it does, make sure the universal joints are operating properly without binding, noise or looseness. Listen for any noise from the centre bearing (if equipped), indicating it's worn or damaged. Also check the rubber portion of the centre bearing for cracking or separation, which will necessitate renewal.

5 The universal joint can also be checked with the driveshaft motionless, by gripping your hands on either side of the joint and attempting to twist the joint. Any movement at all in the joint is a sign of considerable wear. Lifting up on the shaft will also indicate movement in the universal joints.

6 Finally, check the driveshaft mounting bolts at the ends to make sure they're tight.

11 Driveshaft - removal and refitting

Refer to illustrations 11.3, 11.11, 11.13a and 11.13b

REMOVAL

1 Raise the vehicle and support it securely on jackstands. Block the front wheels to prevent the vehicle from rolling.

11.3 Scribe a line across the pinion flange, the U-joint and driveshaft so you can later assemble them in the same positions. Use a large screwdriver to hold the shaft from turning while loosening the bolts

2 Place the transmission in Park or Neutral with the parking brake off.

3 Make reference marks on the driveshaft and the pinion flanges in line with each other (see illustration). This is to make sure the driveshaft is refitted in the same position to preserve the balance.

4 Remove the entire exhaust system from the rear of the catalytic converter to the rear bumper. V6 models with manual transmissions require the removal of the entire exhaust system to the point where it attaches to the exhaust manifolds.

V8 models with manual transmissions

5 Use paint or a scribe to mark the exact position of each end of the rear transmission crossmember where it contacts the frame.

***Caution:** If this is not done, there is a high probability of vibration and/or handling problems after assembly.*

6 Support the rear of the transmission with a floor jack, taking its weight off of the rear mount.

***Note:** Use a block of wood on the jack to avoid damaging the transmission.*

7 Remove the vehicle speed sensor from the rear of the transmission and tie it aside with wire.

8 Remove the bolts which secure the crossmember to the frame.

9 Lower the rear of the transmission.

V6 models with manual transmissions

10 Unbolt the front of the driveshaft from the rear of the transmission. Discard the nuts; they must be renewed during assembly.

All models

11 Use a scribe to mark the exact position of the driveshaft centre support bearing bracket and bolts (see illustration). Remove the bolts and the spacers from the driveshaft centre support bearing.

***Caution:** Do not allow the driveshaft to flex more than 8 degrees to avoid damage to the joint or the boot.*

12 Unbolt the centre support bearing. Note the locations of shims.

13 Remove the nuts and bolts securing the rear of the driveshaft to the rear axle pinion flange (see illustrations).

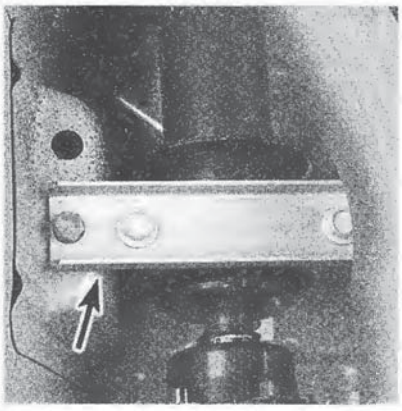
14 Lower the rear of the driveshaft. Slide the front of the driveshaft rearward.

***Caution:** On V8 models equipped with manual transmissions, take care to avoid damage to the speed sensor ring which is exposed at the front of the driveshaft.*

15 On models equipped with an automatic transmission, wrap a plastic bag over the transmission extension housing and secure it in place with a rubber band. This will prevent loss of fluid and protect against contamination while the driveshaft is out.

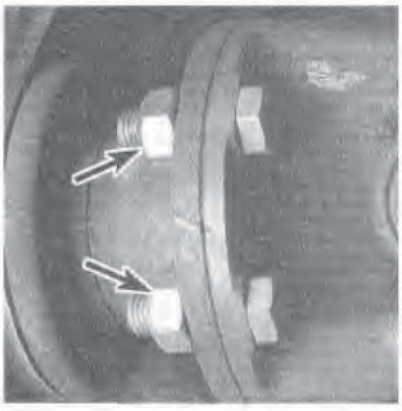
REFITTING

16 Remove the plastic bag from the transmission and wipe the area clean (automatic transmission models). Inspect the

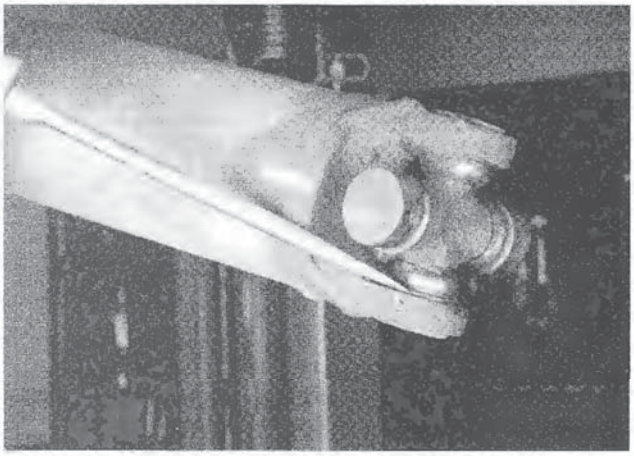


11.11 Mark the location of the centre support (arrow) before you remove it and note the number and location of shims

11.13a Make matching marks from the yoke to the flexjoint (flexible joint shown)



11.13b After match marking the components, remove the nuts (arrows)



12.2 Remove the snap-rings from the U-joint by tapping them off with a screwdriver and hammer

12.3 Press out the cups using a vice and two sockets of the appropriate size

oil seal carefully. Procedures for renewal of this seal can be found in Chapter 7B.

17 Assemble the front of the driveshaft to the transmission. Use new nuts where required.

18 Raise the centre support bearing into place and bolt it to the vehicle, aligning the marks previously made. Refit the shims in their original locations. Tighten the bolts securely.

19 Raise the rear of the driveshaft into position, checking to be sure the marks are in alignment. If not, turn the rear wheels to match the pinion flange and the driveshaft. Tighten all bolts to the torque listed in this Chapter's Specifications, using new nuts. Lower the vehicle.

12 Universal joints - renewal

Refer to illustrations 12.2, 12.3, 12.4a, 12.4b and 12.10

Note: *Always purchase a universal joint service kit(s) for your model vehicle before starting the procedure which follows. Also, read through the entire procedure before beginning work.*

1 Remove the driveshaft (refer to Section 11).

2 Place the shaft on a workbench equipped with a vice. Remove the snap-rings from the insides of the bearing cups (see illustration).

3 Place the universal joint in the vice with a large socket against one ear of the shaft yoke and a smaller socket placed on the opposite bearing cup (see illustration).

Caution: *Never clamp the driveshaft tubing itself in a vice, as the tube may be bent.*

4 Press the bearing cup out of the yoke ear (see illustrations).

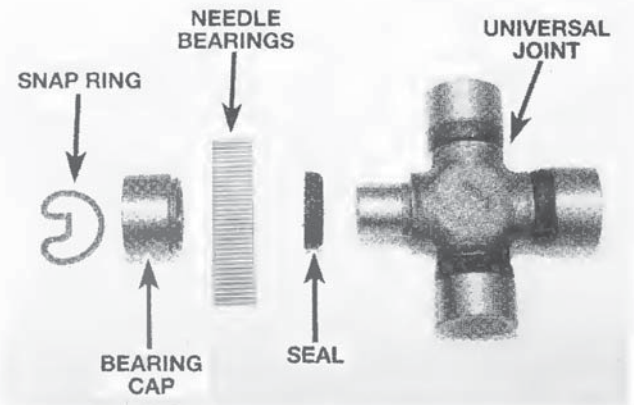
Note: *If the cup does not come all the way out of the yoke, it may be pulled free with adjustable pliers, then removed.*

5 Turn the driveshaft 180-degrees and press the opposing bearing cup out of the yoke.

6 Disengage the cross from the yoke and remove the cross. Repeat Steps 3 through 5 to remove the remaining cups.

7 Press the bearing cups from the slip yoke as detailed above.

8 When reassembling the driveshaft, be sure to use all parts included in the U-joint service kit.



12.4a Exploded view of a typical universal joint

12.4b After it has been pressed out, remove the bearing cup from the yoke ear

12.10 Assemble the new cross and bearing cups

9 Using multi-purpose grease to retain the needle bearings, assemble the bearings, cups and washers. Make sure the bearings do not become dislodged during the assembly and refitting procedures.

10 In the vice, assemble the cross and cups in the yoke, refitting the cups as far as possible by hand (see illustration).

11 Move the cross back and forth horizontally to assure alignment, then press the cups into place a little at a time, continuing to centre the cross to keep the proper alignment.

12 As soon as one snap-ring groove clears the inside of the yoke, stop pressing and fit the snap-ring.

13 Continue to press on the bearing cup until the opposite snap-ring can be fitted. If difficulty is encountered, strike the yoke sharply with a hammer. This will spring the yoke ears slightly and allow the snap-ring groove to move into position.

14 Refit the driveshaft (see Section 11).

13 Driveshaft front flexible joint - renewal

Note: *Flexible joints are used at the front of all manual transmission driveshafts. Conventional universal joints are used on all automatic transmission-equipped vehicles.*

V6 MODELS

1 Remove the driveshaft (see Section 11).

2 Hold the unit using a long screwdriver inserted between the driveshaft yoke and the flexible joint.

3 Remove the three mounting nuts. Discard them.

4 Refitting is the reverse of removal. Tighten the bolts to the torque listed in this Chapter's Specifications. Use new mounting nuts.

V8 MODELS

5 Remove the driveshaft (see Section 11).

6 Hold the unit using a long screwdriver inserted between the driveshaft yoke and the flexible joint.

7 Remove the three bolts securing the yoke to the assembly. Remove the yoke, being careful to avoid damaging the speed sensor ring.

8 Remove the nuts and bolts which secure the flexible joint to the driveshaft. Discard the nuts.

9 Lift the flexible joint off. Do not lose the spacers which are between the driveshaft and the joint.

10 Refitting is the reverse of removal. Tighten the bolts to the torque listed in this Chapter's Specifications. Use new mounting nuts. Use Loctite 242 or its equivalent on the threads of the bolts which secure the yoke to the assembly.

14 Driveshaft constant velocity (CV) joint - renewal

Refer to illustrations 14.3, 14.5, 14.6, 14.8a and 14.8b

Note: *This procedure requires the use of a hydraulic press. It is recommended that the operation be done only by an experienced shop which is equipped with the necessary tools.*

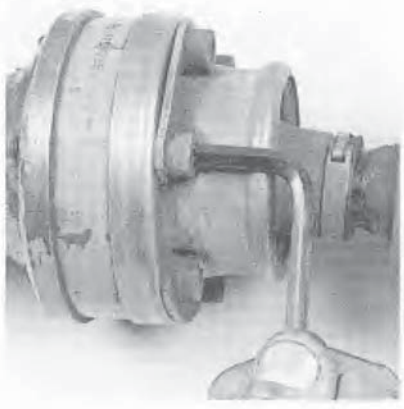
1 Remove the driveshaft (see Section 11).

2 Mark the alignment of the front driveshaft, the rear driveshaft and the CV joint using a straightedge.

3 Remove the socket head cap screws which secure the rear shaft to the CV joint (see illustration).

4 Tap the adapter off of the CV joint using a soft faced hammer.

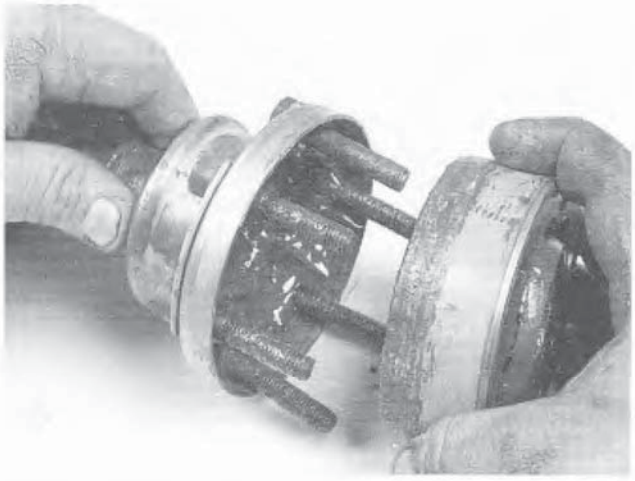
5 Remove the snap-ring (see illustration).



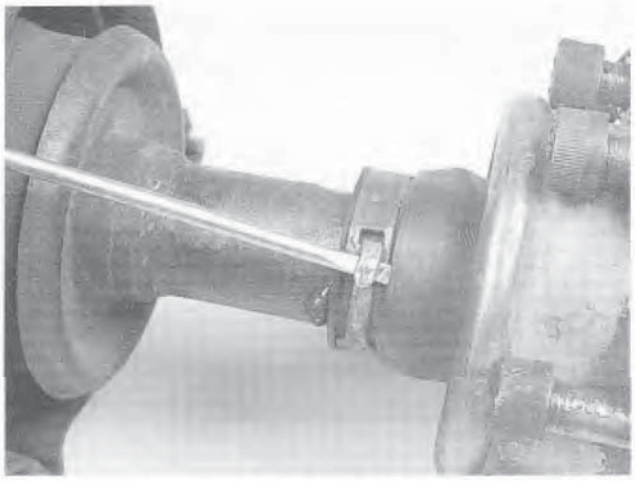
14.3 Remove the Allen head cap screws

14.5 Remove the snap-ring

14.6 Carefully force back the dust boot retainer



14.8a Separate the CV joint from the assembly



14.8b Loosen the clamp to remove the rubber dust boot

6 Remove the dust cover strap. Tap the dust shield off with a soft-faced hammer (see illustration).
7 Disassemble and remove the centre bearing carrier.
8 Using a hydraulic press, press the shaft out of the joint (see illustration). Place the press plates between the dust shield and the joint. Remove the thrust washer and the dust shield (see illustration).
9 Thoroughly clean all parts. Work in a clean environment to ensure the finished job will be free of dust and dirt.
10 Renew any rubber components that show signs of deterioration. Renew all gaskets.
11 Pack the assembly with the molybdenum disulfide grease supplied with the new joint.
12 Apply sealant around the companion flange and dust shield retainer mating points.
13 Apply sealant to the rear shaft flange and the screw threads.
14 The remainder of the procedure is the reverse of the disassembly.

15 Centre support bearing - removal and refitting

Note 1: *This procedure requires the use of a hydraulic press. It is recommended that the operation be done only by an experienced shop which is equipped with the necessary tools.*

Note 2: *The unit will be damaged upon disassembly. Disassemble it only if you know that it must be renewed.*

1 Remove the driveshaft (see Section 11).
2 Remove the CV joint assembly (see Section 14).
3 Bend the tabs and then remove the upper and lower centre cup guides.
4 Remove the rear grease slinger using a hammer and punch. It will now have to be renewed.
5 Remove the bearing circlip.
6 Press the centre bearing from the driveshaft. If you do not have access to a press, take the driveshaft to an automotive repair shop which is willing to perform the press work.

Note: *Don't damage the front grease slinger. It is attached to the front driveshaft.*

7 Drive off the front bearing grease slinger with a hammer and punch.
8 Make certain that all components are kept very clean during reassembly.
9 Renew any rubber parts that show signs of deterioration.
10 Press the new bearing into place in the rubber cup housing until the rubber retainer bead can be seen.
11 Press the bearing and cup onto the driveshaft.
12 Refit the circlip.
13 Renew the rear grease slinger.
14 The rest of the procedure is the reverse of removal.

16 Rear axle - description, check and identification

Refer to illustration 16.7

DESCRIPTION

1 When the vehicle goes around a corner, the differential allows the outer rear tyre to turn more quickly than the inner tyre. The driveaxles are splined to the differential side gears, so when the vehicle goes around a corner, the inner tyre, which turns more slowly than the outer tyre, turns its side gear more slowly than the outer tyre turns its side gear. The differential pinion (or "spider") gears roll around the slower side gear, driving the outer side gear - and tyre - more quickly. The differential is housed within a casting with a cover, known as the "carrier."
2 The independent suspension rear axle has the centre final drive carrier mounted directly to the crossmember of the car. Two driveaxles connect the rear wheels to the carrier with a constant velocity joint at each of their ends. In this arrange-

16.7 All rear axle assemblies have an identification label affixed to them

ment, the final drive unit is mounted solidly to the vehicle while the wheels are suspended independent of each other.

3 An optional limited-slip rear axle is available. This differential allows for normal operation until one wheel loses traction. A limited-slip unit is similar in design to a conventional differential, except for the addition of a pair of clutch "cones" which slow the rotation of the differential case when one wheel is on a firm surface and the other on a slippery one. The difference in wheel rotational speed produced by this condition applies additional force to the pinion gears and through the cone, which is splined to the side gear shafts, equalises the rotation speed of the driveaxle driving the wheel with traction.

CHECK

4 Often, a suspected "axle" problem lies elsewhere. Do a thorough check of other possible causes before assuming the axle is the problem.

5 The following noises are those commonly associated with axle diagnosis procedures:

a) Road noise is often mistaken for mechanical faults. Driving the vehicle on different surfaces will show whether the road surface is the cause of the noise. Road noise will remain the same if the vehicle is under power or coasting.

b) Tyre noise is sometimes mistaken for mechanical problems. Tyres which are worn or low on pressure are particularly susceptible to emitting vibrations and noises. Tyre noise will remain about the same during varying driving situations, where axle noise will change during coasting, acceleration, etc.

c) Engine and transmission noise can be deceiving because it will travel along the driveline. To isolate engine and transmission noises, make a note of the engine speed at which the noise is most pronounced. Stop the vehicle and place the transmission in Neutral and run the engine to the same speed. If the noise is the same, the axle is not at fault.

6 Because of the special tools needed, overhauling the differential isn't cost effective for a do-it-yourselfer. The procedures included in this Chapter describe axleshaft removal and refitting, axleshaft oil seal renewal and removal of the entire unit for repair or renewal. Any further work should be left to a dealer service department or other qualified repair facility.

IDENTIFICATION

7 If the rear axle must be renewed, refer to the identification code and manufacturer's code (see illustration). This number contains information on the rear axle ratio, differential type, manufacturer and build date information, all of which are necessary to ensure that you get the right axle. This information is printed on a label attached to the cover of the differential.

17 Pinion oil seal - renewal

Refer to illustrations 17.3, 17.4 and 17.5

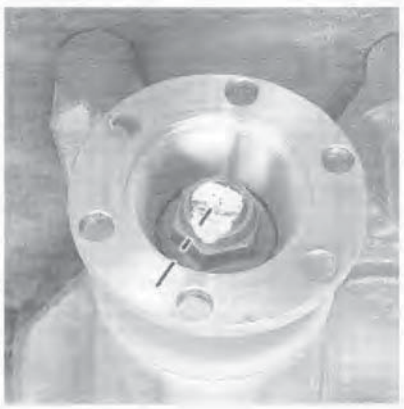
1 Raise the rear of the vehicle and support it securely on jackstands. Block the front wheels to keep the vehicle from rolling off the stands.

2 Disconnect the driveshaft and fasten it out of the way (see Section 11).

3 Use a beam-type or dial-type torque wrench to check the torque required to rotate the pinion. Record the torque value for use later (see illustration).

4 Scribe, paint or punch alignment marks on the pinion shaft, nut and flange (see illustration).

17.3 Use a torque wrench to check the torque necessary to rotate the pinion



17.4 Mark the exact positions of the pinion, nut and flange before removing the nut

17.5 If you don't have a special holding tool, use a large lever and two bolts to hold the pinion flange from turning while you remove the nut

5 A special tool can be used to keep the companion flange from moving while the self-locking pinion nut is loosened. If the special tool isn't available, try using a lever inserted between two bolts which have been secured in the pinion flange (see illustration).

6 Remove the pinion nut.

7 Pull off the companion flange. It may be necessary to use a two or three-jaw puller engaged behind the flange to draw it out. Do not attempt to prise behind the flange or hammer on the end of the pinion shaft.

8 Prise out the old seal and discard it.

9 Apply a non-hardening sealant to the outside edge of the seal. Lubricate the lips of the new seal with multi-purpose grease and tap it evenly into position with a seal driver or a large socket. Make sure it enters the housing squarely and is tapped in to its full depth.

10 Align the mating marks made before disassembly and refit the companion flange. If necessary, tighten the pinion nut to draw the flange into place. Do not try to hammer the flange into position.

11 Apply non-hardening sealant to the ends of the splines visible in the centre of the flange so oil will be sealed in.

12 Refit the washer (if equipped) and pinion nut. Tighten the nut until the marks made in Step 4 are aligned.

13 Measure the torque required to rotate the pinion and tighten the nut in small increments until it matches the figure recorded in Step 3. In order to compensate for the drag of the new oil seal, the nut should be tightened more until the rotational torque of the pinion exceeds the earlier recording by approximately 0.5 Nm (but not to exceed a total rotational torque of 1.2 Nm). Be very careful and do not over-tighten the pinion nut and do not back-off the pinion nut after it has been tightened.

14 Connect the driveshaft and lower the vehicle.

18 Rear axles - removal and refitting

INDEPENDENT REAR SUSPENSION

Refer to illustration 18.3

> ***Note:*** *Renewal of the CV joint boots or the CV joints requires the use of a hydraulic press. We recommend that you take your removed driveaxle to a well equipped repair shop for these procedures or you may simply purchase a rebuilt driveaxle. The rebuilt driveaxle will include two new constant velocity joints and boots, ready for you to refit.*

1 Raise the vehicle and support it securely on jackstands. Set the parking brake firmly. Block the front wheels to prevent the vehicle from rolling.

2 Mark the ends of the driveaxle to note which end connects to the differential side gear shaft.

3 Raise the rear suspension arm with a floor jack to decrease the angle on the CV joints. Remove the bolts securing the inner and outer constant velocity joints to the hub and the differential side gear shaft (see illustration). This will require an 8 mm Allen key socket. Do not allow the joints to deflect any more than necessary. Do not allow the axle to hang from a joint. Remove the driveaxle assembly.

4 Refitting is the reverse of removal. Torque the bolts to the specification listed in this Chapter.

SOLID AXLES

Refer to illustrations 18.10 and 18.12

5 Raise the rear of the vehicle and support it securely on jackstands and remove the relevant wheel.

6 Remove the brake caliper anchor plate retaining bolts and lift the caliper off the brake disc (see Chapter 9).

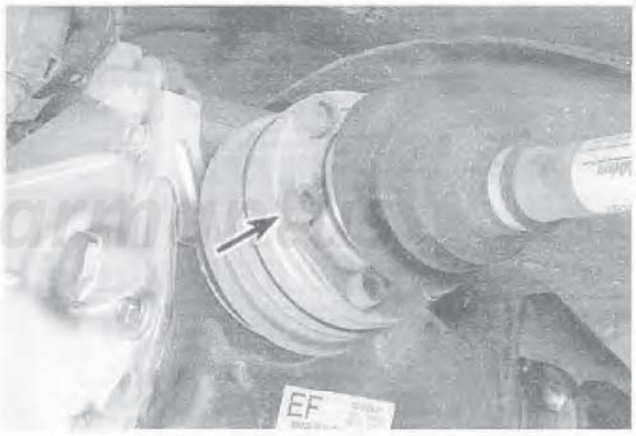
7 Place a spacer approximately as thick as the brake disc between the brake pads and support or suspend the caliper out of the way without stretching the brake hose.

8 Ensure the handbrake is in the Off position and remove the brake disc from the axle.

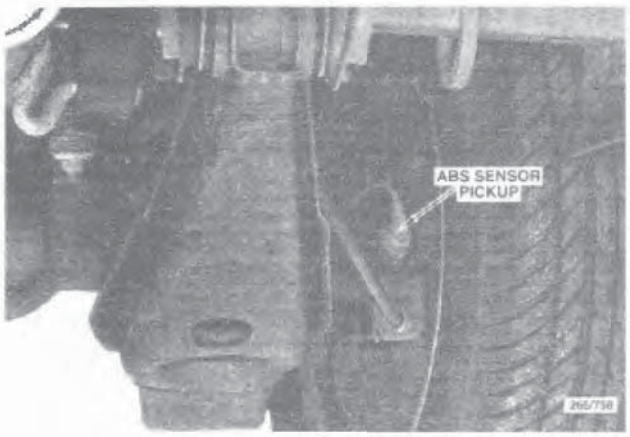
9 Prior to removal of the axle shaft, measure the axle shaft end float. Mount a dial gauge with the plunger positioned against the axle flange and move the axle shaft in and out. If the end float is excessive, the axle bearing must be renewed.

10 On models with ABS, remove the sensor pickup retaining bolt and ease the sensor from the axle housing using a twisting motion. Do not pull on the wiring, pull only on the body of the sensor (see illustration). Tie the sensor to a convenient place on the underbody where it will not be damaged.

11 Working through the access hole in the axle flange, remove the nuts from the axle shaft retainer.

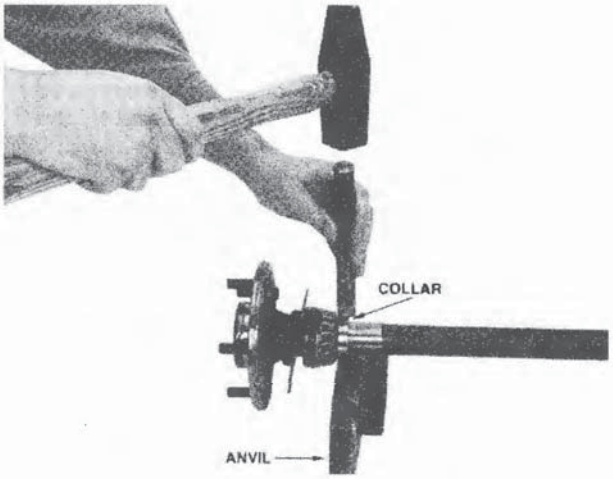


18.3 Allen bolts secure the CV joints to the side gear shafts as well as the wheel hubs. Don't let the axle hang by one joint as you work on the other - support it with wire



18.10 Typical ABS sensor pickup location - utility model shown

18.12 Use the brake disc as a slide hammer puller



20.5 Use a cold chisel to remove the axle bearing retaining collar

12 Using a slide hammer secured to the axle shaft, remove the axle shaft. On models with ABS, use extreme caution not to damage the speed sensor pulse ring on the bearing cup while removing the axle shaft. If the pulse ring is damaged, it must be renewed.

> ***Note:*** *If a puller is not available, reverse the brake disc (see illustration) and loosely install it on the axle flange bolts with the wheel nuts. Use the disc assembly as a slide hammer type puller. Under no circumstances should the disc be hammered.*

13 If the bearing cup is to be removed from the axle housing, a slide hammer with a suitable adaptor will be required.

14 Installation is a reversal of the removal procedure with attention to the following details.

15 Check that the oil drain hole in the backing plate and flange is clear.

16 If the old bearing is being reused and the cup has pulled away from the outer race, ensure that the hard adhesive is cleaned off before installation.

17 Ensure that the axle shaft engages with the differential side gears.

> ***Note:*** *On vehicles equipped with a limited slip differential, ensure that the axle shaft is not rotated until the opposite axle shaft is installed or misalignment of the cone and side gears will result.*

19 Axle oil seal - removal and refitting

CONSTANT VELOCITY AXLES

1 Remove the driveaxle. Refer to Section 18.

2 Attach a slide hammer to the side gear shaft and pull it out.

> ***Caution:*** *If the car has a limited slip differential, do not let the other side gear shaft rotate. This would require disassembling the final drive unit to realign the gear and cone splines in order to install the side gear shaft.*

3 Use a large screwdriver to prise out the old seal.

4 Apply a non-hardening sealant to the outside of the new seal and rear axle lubricant to the inner edge. Tap in the new seal using a hammer with a large socket.

5 Verify that the side gear shaft is not damaged or burred where it contacts the seal. Refit the side gear shaft without touching the splines to the seal.

6 The remainder of refitting is the reverse of removal. On solid axle models see Section 20.

20 Rear wheel bearing - removal and refitting

INDEPENDENT REAR SUSPENSION

1 Dismantling of the rear hub assembly requires special tools. If there is a problem with the hub assembly or wheel bearing on your vehicle, we recommend that you take the rear suspension arm to a well-equipped repair shop for service. See Chapter 10 for the suspension arm removal procedure.

SOLID AXLES

Refer to illustrations 20.5, 20.9 and 20.16

2 Remove the axle shaft as described in Section 18.

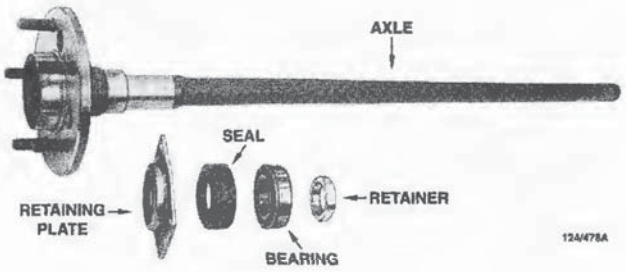
3 On models with ABS, support the axle shaft in a press with a press plate positioned squarely under the pulse ring. Remove the pulse ring from the axle shaft.

4 Drill a 6 mm hole into the bearing retainer at right angles to the axle shaft, ensuring not to drill completely through the retainer as damage to the axle shaft will result.

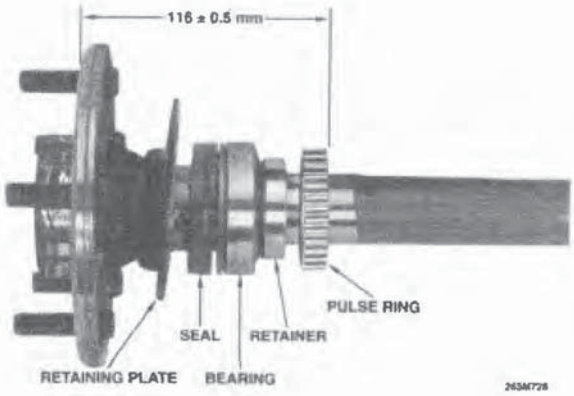
5 Rest the bearing retainer on an anvil, split the retainer with a cold chisel (see illustration) across the hole previously drilled.

6 Using a press and press plates, support the bearing inner cone and press the axle shaft from the bearing. Discard the bearing.

> ***Note:*** *Use of a suitable press and press plates is essential when renewing the bearing. If these are not available, the shaft assembly should be taken to a reliable workshop for bearing installation.*



20.9 Typical exploded view of an axle shaft without ABS



20.16 Measure the distance between the ABS sensor pulse ring and the outer edge of the axle flange. Ensure that the distance is as specified

7 Remove the oil seal and retaining plate from the axle and discard the oil seal.
8 Check the retaining plate for wear or distortion and renew if necessary.
9 Clean the axle shaft and inspect the bearing seat surface and oil seal surface to ensure that there is no damage (see illustration).
10 Refit the retaining plate to the axle shaft with the flat side facing away from the axle flange.
11 Apply grease to the cavity between the sealing lips of the new oil seal and install it to the axle shaft with the lips facing away from the axle flange.
12 Position the new bearing on the axle shaft, ensuring that the machined groove on the outer race is towards the axle flange.
13 Check that the bearing is squarely positioned on the axle shaft and install the new bearing retainer.
14 Press the bearing and retainer on the axle shaft simultaneously using the press and press plates.
15 Lubricate the bearing with the specified lubricant.
16 On models with ABS, position the pulse ring on the axle shaft and carefully press it onto the shaft squarely until the distance between the inner edge of the pulse ring and the outer flange of the axle shaft is 116 ± 0.5 mm (see illustration).
17 Refitting is the reverse of removal.

21 Rear axle assembly - removal and refitting

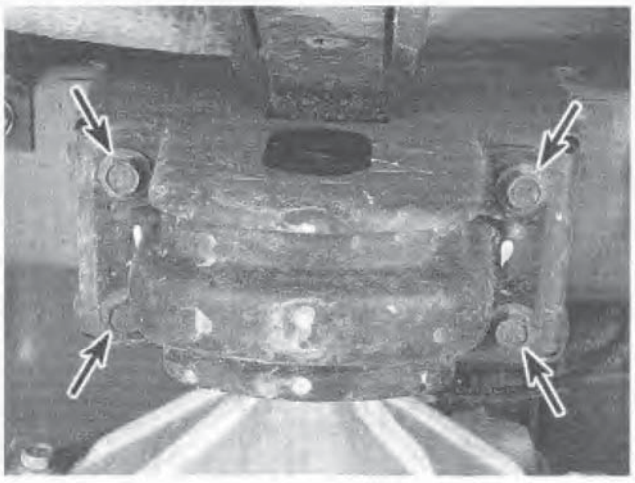
INDEPENDENT REAR SUSPENSION

Refer to illustration 21.8

1 Raise the vehicle and support it securely on jackstands. Remove the rear wheels.
2 Remove the middle and rear sections of the exhaust system.

Note: *It will be necessary to renew the retainers for the rubber supports when reassembling the system.*

3 Disconnect the driveshaft from the final drive assembly. Refer to Section 11.
4 Release the parking brake and disconnect the cable at the front adjuster.
5 Disconnect the cable from the retainers on the body.
6 Disconnect the brake hoses from the tubes at the rear trailing arms. Plug the ends of the hoses and tubes. Disconnect the hoses from the brackets.
7 If the vehicle has ABS, disconnect the wiring from each sensor.
8 Scribe the exact location of the rear mount on the body (see illustration).
9 Put a floor jack under the housing and remove the bolts securing the mount to the body. Discard the bolts.
10 Remove the driveaxles from the side gear shafts (refer to Section 18).
11 Remove the rear coil springs (see Chapter 10).
12 Loosen the two rear mount bolts from the rear cover. Jack up the centre section as far as possible.
13 Remove the bolts securing the brace to the body.



21.8 Scribe the exact position of the rear mount, then remove the bolts (arrows)

14 Lower the entire unit and remove it. Have a helper stabilise it on the jack.

15 Unbolt and remove the rear crossmember.

16 Remove the rear mount from the final drive unit.

17 Refitting is the reverse of removal, but take note of the following points:

a) The rear mount to the body surface must be parallel (within 1 mm) to the rear crossmember.

b) When attaching the shock absorbers, the final drive unit will have to be lowered about 60 mm to avoid damage to the CV boots.

c) Align the unit with the scribe marks you made previously when bolting it up.

d) Tighten all fasteners to the torques listed in this Chapter's Specifications.

***Caution:** The bolts for the rear crossmember mount to rear cover, the rear mount to the vehicle body and the differential housing to crossmember must be renewed whenever they are removed.*

SOLID REAR AXLE

Refer to illustration 21.23

18 Raise the rear of the vehicle and support it securely on jackstands. Chock the front wheels and remove the rear wheels.

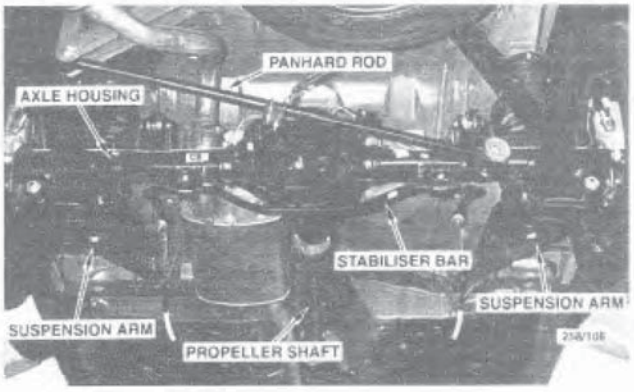
19 Remove the driveshaft (see Section 11).

20 Disconnect both handbrake cables from the actuating levers (see Chapter 9).

21 Disconnect the hose from the underbody brake pipe union and plug the pipe and hose to prevent fluid loss and entry of dirt. On models with ABS, remove the bolts retaining the speed sensors. Gather any shims and secure the sensor to the underbody clear of the work area.

22 Remove the brake hose retaining clip and disconnect the hose from the bracket

23 Raise the rear axle slightly using a trolley jack, disconnect the shock absorber lower mounting bolts and push the shock absorbers up to clear the axle housing (see illustration).



21.23 Typical solid rear axle assembly

24 Remove the nuts, washers and the rubber bushes from the lower ends of the stabiliser bar links and pull the stabiliser bar clear of the links. Remove the nut and washer from the panhard rod lower mounting and push the rod up out of the way.

25 Lower the jack and axle assembly sufficiently to remove the coil springs. Remove the coil springs and insulators from the vehicle.

26 Remove the bolts and nuts securing the rear axle assembly to upper and lower suspension arms.

27 Ensure that the rear axle is securely supported by a trolley jack. Disconnect the upper suspension arms from the axle housing, slightly raise and move the assembly rearwards to clear the lower suspension arms. Lower the jack and remove the assembly from the vehicle.

28 Refitting is the reverse of removal.

29 Final tightening of the bolts should be done with the vehicle lowered to the ground and the suspension at normal ride height.

30 Bleed the brakes (see Chapter 9).

31 Fill the rear axle with the specified grade and quantity of lubricant.

Chapter 9
Brakes

Contents

Specifications

General

Brake fluid type	DOT 4

Disc brakes

Brake pad minimum thickness	3 mm
Disc lateral runout limit	
Front	0.04 mm
Rear	0.05 mm total or 0.03 mm in 30 degrees of rotation
Disc minimum thickness	Refer to the marks cast into the disc

Torque specifications	Nm
Booster mounting nuts	20 to 25
Brake hose banjo bolt-to-caliper (front)	
Except VZ SS models from 2006	32 to 37
VZ SS models from 2006	
Step 1	12
Step 2	Tighten an additional 90 degrees
Brake hose banjo bolt-to-caliper (rear)	32 to 37
Brake line fitting nuts	
VT to VY models	8 to 11
VZ models	14
Caliper guide pin bolts (front and rear)	30 to 34
Front caliper mounting bracket bolts	
Except VZ SS models from 2006	32 to 37
Step 1	80 to 90
Step 2	Tighten an additional 45 degrees
VZ SS models from 2006	
Step 1	70
Step 2	Tighten an additional 90 degrees
Master cylinder bracket nuts (VT to VY models)	15 to 20
Master cylinder bracket-to-strut tower nut	10
Master cylinder end plug (VT to VY models)	6 to 14
Master cylinder mounting nuts	
VT to VY models	15 to 20
VZ models	10
Master cylinder reservoir screw	
VT to VY models	4 to 5
VZ models	2.5
Parking brake lever mounting bolts	
1997 and 1998 models	20 to 25
1999 series II models to VY models	35 to 65
VZ models	50
Pressure differential warning switch	2
Rear caliper mounting bracket bolts	70 to 100

1 General information

All vehicles covered by this manual are equipped with hydraulically operated front and rear brake systems. All brake systems are disc type.

The hydraulic system consists of two separate front and rear circuits. The master cylinder has separate reservoirs for the two circuits and in the event of a leak or failure in one hydraulic circuit, the other circuit will remain operative. A visual warning of circuit failure or air in the system is given by a warning light activated by displacement of the piston in the brake distribution (pressure differential warning) switch from its normal "in balance" position.

The parking brake mechanically operates the small drum brake inside the rear disc brake assembly. The parking brake is activated by a pull-handle in the centre console between the front seats.

A proportioning valve is located in the master cylinder on all models. Its purpose is to provide more pressure for the front brakes than for the rear.

The pressure differential warning switch is designed to continuously compare the front and rear brake pressure from the master cylinder and energise the dash warning light in the event of either front or rear brake system failure. The design of the switch and valve are such that the switch will stay in the "warning" position once a failure has occurred. The only way to turn the light off is to repair the cause of the failure and apply a heavy brake pedal force.

The power brake booster, utilising engine manifold vacuum and atmospheric pressure to provide assistance to the hydraulically operated brakes, is located in the engine compartment, mounted on the right side of the firewall.

After completing any operation involving the disassembly of any part of the brake system, always test drive the vehicle to check for proper braking performance before resuming normal driving. When testing the brakes, perform the tests on a clean, dry, flat surface. Conditions other than these can lead to inaccurate test results. Test the brakes at various speeds with both light and heavy pedal force. The vehicle should stop evenly without pulling to one side or the other. Avoid locking the brakes because this slides the tyres and diminishes braking efficiency and control.

Tyres, vehicle load and front-end alignment are factors which also affect braking performance.

Torque values given in the Specifications Section are for dry, unlubricated fasteners.

CALIPERS

All disc brakes used by the vehicles covered in this manual are equipped with a double-pin floating caliper, a single-piston or double-piston design that "floats" on two steel guide pins. When the brake pedal is depressed, hydraulic pressure pushing on the piston is transmitted to the inner brake pad and against the inner surface of the brake disc. As the force against the disc from the inner pad is increased, the caliper assembly moves in, sliding on the guide pins and pulling the outer pad against the disc, providing a pinching force on the disc.

MASTER CYLINDER

The master cylinder is located under the bonnet on the driver's side, and can be identified by the large fluid reservoir on top. The master cylinder has two separate circuits to accommodate the split system.

POWER BRAKE BOOSTER

The power brake booster uses engine manifold vacuum to provide assistance to actuate the brakes. It is mounted on the firewall in the engine compartment, directly behind the master cylinder.

PARKING BRAKE SYSTEM

The parking brake lever actuates the rear brakes via a cable. The parking brake cable pulls on a lever attached to the brake shoe assembly, causing a pair of small brake shoes inside the disc/hub assembly to expand.

PRECAUTIONS

There are some general precautions and warnings related to the brake system:

a) Use only brake fluid conforming to DOT 4 specifications.
b) The brake pads and linings contain fibres which are hazardous to your health if inhaled. Whenever you work on brake system components, clean all parts with brake system cleaner. Do not allow the fine dust to become airborne.
c) Safety should be paramount whenever any servicing of the brake components is performed. Do not use parts or fasteners which are not in perfect condition, and be sure all clearances and torque specifications are adhered to. If you are at all unsure about a certain procedure, seek professional advice. Upon completion of any brake system work, test the brakes carefully in a controlled area before driving the vehicle in traffic.
d) If a problem is suspected in the brake system, don't drive the vehicle until it's fixed.

2 Anti-lock Brake System (ABS) - general information

1 ABS is fitted on most models. On some models it is combined with electronic traction control (ABS/ETC). Models with ABS can be identified by an ABS warning light on the instrument panel and a master cylinder with only two outlet lines.

2 A four-wheel Anti-lock Brake System (ABS) maintains vehicle manoeuvrability, directional stability, and optimum deceleration under severe braking conditions on most road surfaces. It does so by monitoring the rotational speed of the wheels and controlling the brake line pressure to the wheels during braking. This prevents the wheels from locking up on slippery roads or during hard braking. This system is complex and has components located at many points in the vehicle.

HYDRAULIC MODULATOR/CONTROL MODULE ASSEMBLY

3 The hydraulic modulator/control module assembly, mounted in the engine compartment, controls hydraulic pressure to the calipers by modulating hydraulic pressure to prevent wheel lock-up.

4 The control module is located on the modulator. It monitors the ABS system and controls the anti-lock valve solenoids. It accepts and processes information received from the brake switch and wheel speed sensors to control the hydraulic line pressure and avoid wheel lock up. It also monitors the system and stores fault codes which indicate specific problems.

5 Each sensor assembly consists of a variable reluctance sensor mounted adjacent to a "toothed ring" with an air gap

between them. A wheel speed sensor and toothed ring are mounted in the hub/disc unit of each front wheel. Two more sensors are mounted on the rear final drive housing. The air gap between the sensors and the rings is not adjustable and the sensors themselves are not rebuildable.

6 A wheel speed sensor measures wheel speed by monitoring the rotation of the toothed ring. As the teeth of the ring move through the magnetic field of the sensor, an AC voltage is generated. This signal frequency increases or decreases in proportion to the speed of the wheel. The module monitors these signals for changes in wheel speed; if it detects the sudden deceleration of a wheel, i.e. wheel lockup, it activates the ABS system.

7 If the ABS OFF light on the dash comes on while you're driving, there is a fault somewhere in the ABS system and the ABS system may be inoperative, but the brakes should still function in their non-ABS mode. Take the vehicle to a dealer service department or other qualified repair shop immediately and have the ABS serviced.

8 Although a special electronic tester is necessary to properly diagnose the system, the home mechanic can perform a few preliminary checks before taking the vehicle to a dealer service department which is equipped with this tester.

a) Make sure the brake calipers are in good condition.
b) Check the electrical connector at the controller.
c) Check the fuses and relays.
d) Follow the wiring harness to the speed sensors and brake light switch and make sure all connections are secure and the wiring isn't damaged.
e) Make sure that all the toothed rings and sensors do not have obvious damage.

9 If the above preliminary checks don't rectify the problem, the vehicle should be diagnosed by a dealer service department.

10 There is a valve relay and a pump motor relay located under the modulator cover.

11 An ABS fusible link (labelled FR) is in the fusible link box in the engine compartment. There is also a 10 amp ABS fuse in the passenger compartment fuse panel to the right of the steering column.

3 Disc brake pads - renewal

Refer to illustrations 3.3 and 3.4a through 3.4k

***Warning:** Disc brake pads must be renewed on both front or rear wheels at the same time - never renew the pads on only one wheel. Also, the dust created by the brake system is harmful to your health. Never blow it out with compressed air and don't inhale any of it. An approved filtering mask should be worn when working on the brakes. Do not, under any circumstances, use petroleum-based solvents to clean brake parts. Use brake system cleaner only!*

***Note:** This procedure applies to both the front and the rear disc brakes.*

1 Loosen the wheel lug nuts, raise the vehicle and support it securely on jackstands. Remove the wheels.

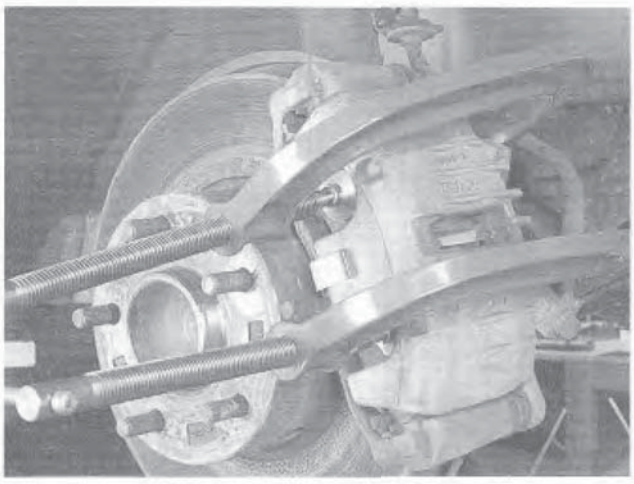
2 Remove about two-thirds of the fluid from the master cylinder reservoir and discard it. Position a drain pan under the brake assembly and clean the caliper and surrounding area with brake system cleaner.

3 Push the piston back into its bore to provide room for the new brake pads with a G-clamp (see illustration). As the piston is depressed to the bottom of the caliper bore, the fluid in the master cylinder will rise. Make sure it doesn't overflow. If necessary, siphon off some of the fluid.

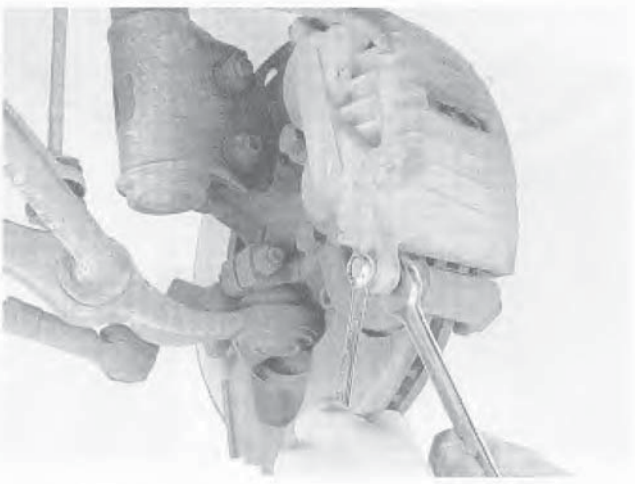
4 To renew the brake pads, follow the accompanying photos, beginning with illustration 3.4a. Be sure to stay in order and read the caption under each illustration.

***Note:** The rear brake pads use shims which must be refitted in the correct positions. The full shim is fitted to the outboard pad. The half shim is fitted to the upper part of the inboard pad.*

5 While the pads are removed, inspect the caliper for brake fluid leaks and ruptures of the piston boot. Overhaul or renew the caliper as necessary (see Section 4). Also inspect the brake disc carefully (see Section 5). If machining is necessary, follow the information in that Section to remove the disc.



3.3 Retract the caliper piston with a G-clamp. On front calipers there are two pistons, so you will need a pair of them



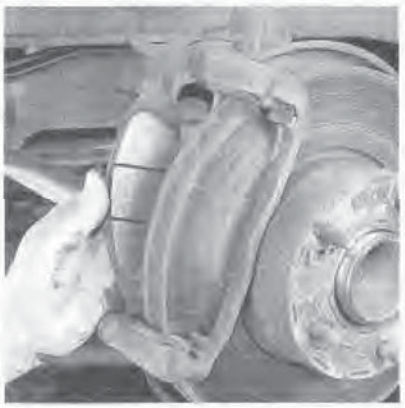
3.4a To remove a caliper, you must remove these bolts. Use a back-up spanner to hold the inner guide pins, then remove the guide pin bolts

6 Make certain that the guide pins can move freely. They should be carefully cleaned and inspected. Also inspect the rubber boots for deterioration. Lubricate the pins with a small amount of special brake lubricant or anti-seize.

Note: *If the calipers do not slide freely on the guides, premature wear may occur on one pad only. One pad may also generate excessive heat because it is constantly in contact with the disc.*

3.4b Hang the caliper with a piece of wire - don't let it hang by the brake hose

3.4c On front calipers, take out the outer brake pad - note the position of the anti-rattle spring



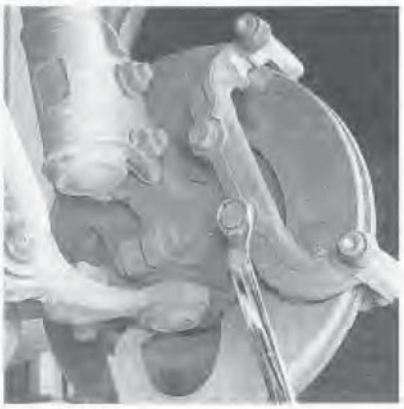
3.4d On front calipers, remove the inner brake pad

3.4e On front calipers, remove the anti-rattle spring from the bottom ...

3.4f ... and the top of the mounting bracket

3.4g On rear calipers remove the inner pad first ...

3.4h ... followed by the outer pad



3.4i If the disc is to be removed, remove the bolts and detach the caliper mounting bracket

3.4j Pull the caliper guide pins out of their sleeves, clean and inspect them for wear. Lubricate with high temperature grease and refit them in the mounting bracket

7 Renew the caliper bolts with new ones. They are self-locking and are designed to be used one time only. Be sure to tighten the caliper guide pin bolts to the torque listed in this Chapter's Specifications.

8 Refit the brake pads on the opposite wheel, then refit the wheels and lower the vehicle. Tighten the lug nuts to the torque listed in the Chapter 1 Specifications. Add brake fluid to the reservoir until it's full (see Chapter 1).

9 Pump the brakes several times to seat the pads against the disc, then check the fluid level again.

Warning: *Failure to do this will result in a temporary "no brakes" condition.*

10 Check the operation of the brakes before driving the vehicle in traffic. Try to avoid heavy brake applications until the brakes have been applied lightly several times to seat the pads.

4 Disc brake caliper - removal, overhaul and refitting

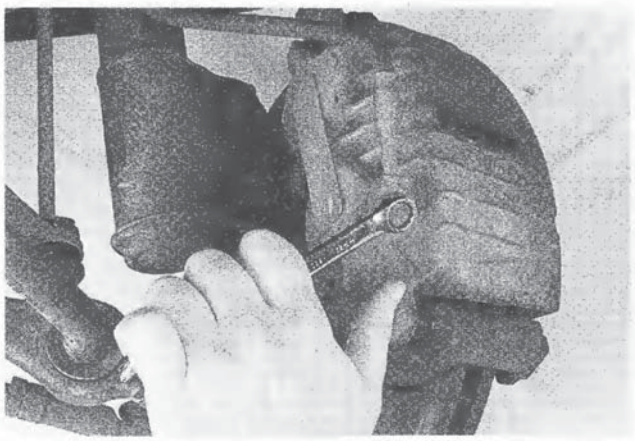
Warning: *Dust created by the brake system is harmful to your health. Never blow it out with compressed air and don't inhale any of it. An approved filtering mask should be worn when working on the brakes. Do not, under any circumstances, use petroleum-based solvents to clean brake parts. Use brake system cleaner only.*

Note: *If an overhaul is indicated (usually because of fluid leaks, a stuck piston or broken bleeder screw) explore all options before beginning this procedure. New and factory rebuilt calipers are available on an exchange basis, which makes this job quite easy. If you decide to rebuild the calipers, make sure rebuild kits are available before proceeding. Always rebuild or renew the calipers in pairs - never rebuild just one of them.*

REMOVAL

Refer to illustration 4.2

1 Loosen the wheel lug nuts, raise the vehicle and support it securely on jackstands. Remove the wheels.



4.2 Remove the banjo bolt and detach the brake hose from the caliper

3.4k Coat the back of the inner front pad with anti-squeal compound, following the manufacturer's instructions. Refit the pads by reversing the removal procedure

2 Unscrew the banjo bolt from the caliper and detach the hose (see illustration).

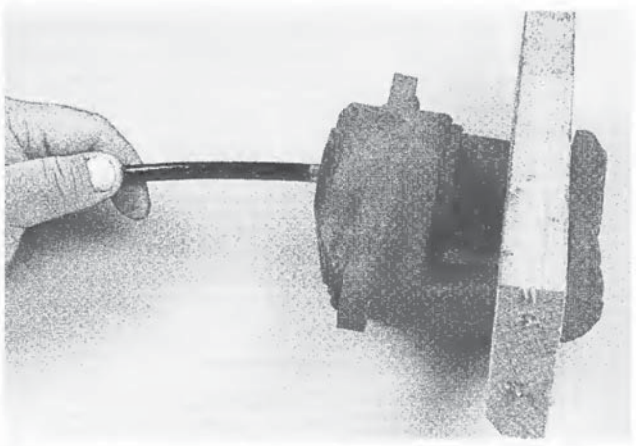
Note: *If you're just removing the caliper for access to other components, don't disconnect the hose. Discard the sealing washers and use new ones during refitting. Plug the end of the hose to prevent fluid loss and contamination.*

3 Refer to the first few Steps in Section 3 (caliper removal is the first part of the brake pad renewal procedure). Clean the caliper assembly with brake system cleaner. DO NOT use kerosene, petrol or petroleum-based solvents. Be sure to check the pads as well and renew them if necessary (see Section 2).

OVERHAUL

Refer to illustrations 4.4, 4.6, 4.7 and 4.12

4 Place several shop towels or a block of wood in the centre of the caliper to act as a cushion, then use compressed air, directed into the fluid inlet, to remove the piston (see illustration). Use



4.4 With a block of wood placed between the piston and the caliper frame, use compressed air to ease the piston out of the bore

4.6 Remove the dust boot from the caliper

4.7 The piston seal should be removed with a plastic or wooden tool to avoid damage to the bore and the seal groove (a pencil will do the job)

4.12 Slip the boot over the piston and push the piston to the bottom of the bore

only enough air pressure to ease the piston out of the bore. If the piston is blown out, even with the cushion in place, it may be damaged.

Warning: *Never place your fingers in front of the piston in an attempt to catch or protect it when applying compressed air, as serious injury will almost certainly occur.*

5 If you are working on a front caliper with two pistons, the above method will only remove one of them. The other piston can be removed by grasping it with snap-ring pliers and twisting it from its bore.

6 Remove the dust boot from the caliper bore (see illustration).

7 Using a wood or plastic tool, remove the piston seal from the groove in the caliper bore (see illustration). Metal tools may cause bore damage.

8 Remove the bleeder screw, then remove and discard the guide pin bushes and sleeves.

9 Clean the remaining parts with brake system cleaner or clean brake fluid, then blow them dry with filtered, unlubricated compressed air.

10 Inspect the surfaces of the piston for nicks and burrs and loss of plating. If surface defects are present, the caliper must be renewed. Check the caliper bore in a similar way. Light polishing with crocus cloth is permissible to remove slight corrosion and stains on the bore only. Do not polish the piston. Discard the caliper pins if they're severely corroded or damaged.

11 Lubricate the new piston seal with clean brake fluid and position the seal in the cylinder groove using your fingers only.

12 Fit the new dust boot in the upper groove in the caliper bore. Dip the piston in clean brake fluid and insert it into the boot, then depress it squarely into the cylinder (see illustration).

13 Depress the piston to the bottom of the cylinder bore.

14 Fit the new guide pin boots and bushes.

15 Refit the bleeder screw and tighten it securely.

REFITTING

16 Refit the caliper assembly, tightening the caliper guide pin bolts to the torque listed in this Chapter's Specifications. The bolts must be new ones as they are self-locking. Do not reuse the old bolts.

17 Connect the brake hose to the caliper using new sealing washers. Tighten the banjo bolt to the torque listed in this Chapter's Specifications.

18 Bleed the brakes (see Section 8).

19 Refit the wheels and lug nuts. Lower the vehicle and tighten the lug nuts to the torque listed in the Chapter 1 Specifications.

20 After the job has been completed, firmly depress the brake pedal a few times to bring the pads into contact with the disc.

Warning: *Failure to do this will result in a temporary "no brakes" condition.*

21 Check the operation of the brakes before driving the vehicle in traffic.

5 Brake disc - inspection, removal and refitting

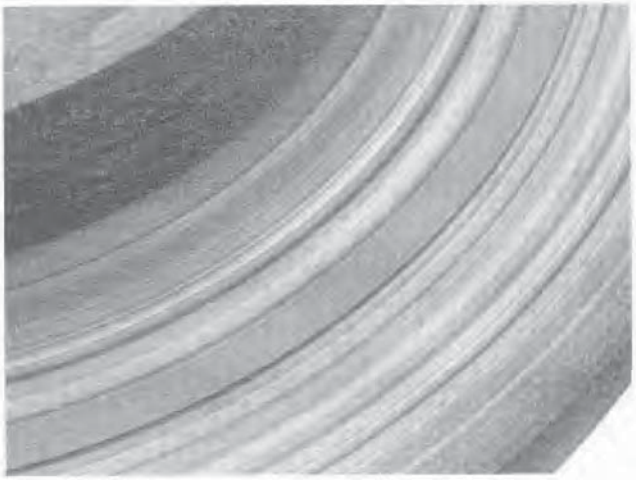
Refer to illustrations 5.3 and 5.4

1 Loosen the wheel lug nuts, raise the vehicle and place it securely on jackstands. Remove the wheel.

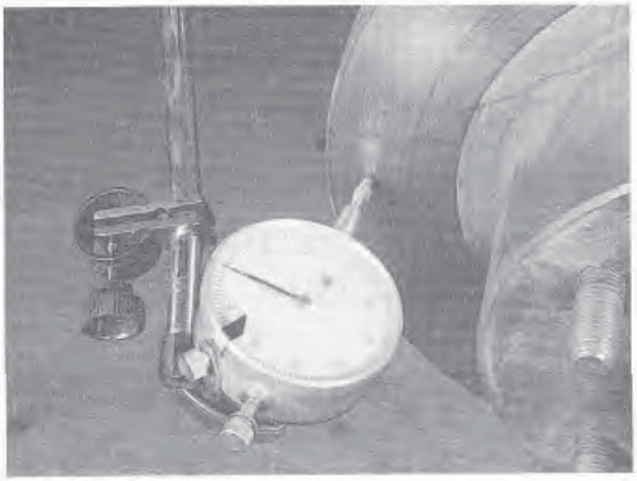
2 Remove the caliper and caliper mounting bracket (see Section 3). It is not necessary to disconnect the brake hose. After removing the caliper, hang it out of the way on a piece of wire. Never hang the caliper by the brake hose because damage to the hose will occur.

3 Inspect the disc surfaces (see illustration). Light scoring or grooving is normal, but deep grooves or severe erosion is not. If pulsating has been noticed during application of the brakes, suspect disc runout.

4 Attach a dial indicator to the caliper mounting bracket, secure the disc with lug nuts and turn the disc. Note the amount of runout (see illustration). Check both inner and outer surfaces. If the runout is more than the specified allowable maximum, the disc must be removed from the vehicle and taken to an automotive machine shop for resurfacing.



5.3 The brake pads on this vehicle were obviously neglected, as they wore down to the rivets and cut deep grooves into the disc - wear this severe means the disc must be renewed



5.4 Check the runout of the brake disc with a dial indicator

5 Using a micrometer, measure the thickness of the disc. If it is less than the specified minimum, renew the disc. Also measure the disc thickness at several points to determine variations in the surface. Any variation over a very small amount may cause pedal pulsations during brake application. If this condition exists and the disc thickness is not below the minimum, the disc can be removed and taken to an automotive machine shop for resurfacing.

6 If the disc needs to be removed for repair or renewal, first make match marks on it and the hub so that it can be refitted in the same position. For rear discs, make sure that the parking brake is released. Remove the caliper and the caliper mounting bracket (see Section 3).

7 Tap the disc with a soft-faced hammer if it is stuck. Lift it off.

Note: *If the rear discs are held in place by the parking brake shoes, loosen the parking brake shoe adjustment by inserting a screwdriver through the hole in the disc and operating the adjusting wheel.*

8 Installation is the reverse of removal.

6 Master cylinder - removal, overhaul and refitting

REMOVAL

Refer to illustration 6.3

Note: *A master cylinder overhaul kit should be purchased before beginning this procedure. The kit will include all the parts necessary for the overhaul procedure. The rubber parts, particularly the seals, are the key to fluid control within the master cylinder. As such, it's very important that they be refitted securely and facing in the proper directions. Be careful during the rebuild procedure that no grease or mineral-based solvents come in contact with the rubber parts.*

1 Completely cover the front fender and cowling area of the vehicle; brake fluid can ruin painted surfaces if it is spilled.

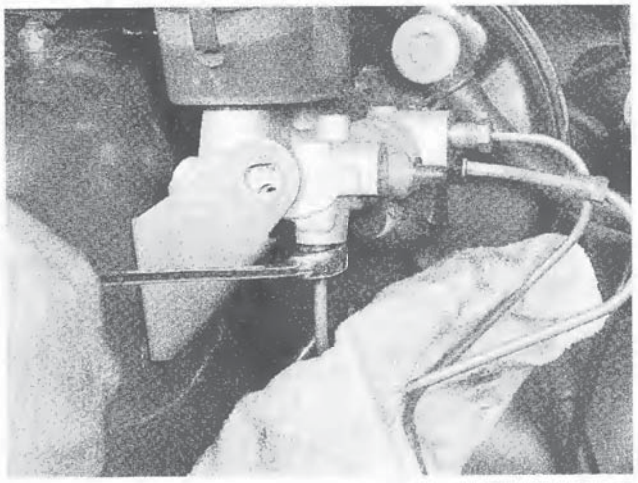
2 Remove the brake fluid from the master cylinder reservoir and discard it.

Caution: *Do not spill brake fluid on painted surfaces. Place rags under the master cylinder assembly and clean the area around the brake line fittings with brake system cleaner.*

3 Disconnect the brake line fittings (see illustration) and the wiring from the pressure differential switch, where fitted. Rags or newspapers should be placed under the master cylinder to soak up the fluid that will drain out.

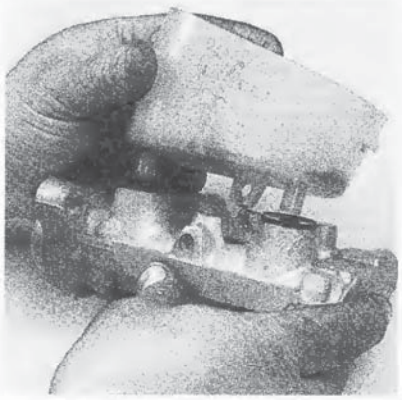
4 Remove the two master cylinder mounting nuts and the support bracket components. Remove the master cylinder from the vehicle. Do not bend the hydraulic lines. Plug the ends of these lines immediately to protect the system from moisture and dirt.

Caution: *Do not press on the brake pedal after the master cylinder has been removed.*



6.3 Remove the brake line fittings from the master cylinder with a flare-nut spanner

6.6a Remove the bolt that secures the reservoir



6.6b The reservoir can then be pulled free of the master cylinder body

6.6c Remove the reservoir seals

OVERHAUL

Refer to illustrations 6.6a, 6.6b, 6.6c, 6.8, 6.9, 6.15, 6.22a and 6.22b

5 Remove the cap from the reservoir and dispose of the fluid.

6 Remove the bolt at the base of the reservoir on the outside (see illustration). Remove the reservoir and the two seals (see illustrations).

7 Turn the unit so that the two reservoir openings point downward and clamp it in a vice. Push in the primary piston. The secondary piston stop will fall out. Remove the primary piston.

8 Tap out the secondary piston along with its spring onto a block of wood (see illustration). Don't try to remove the other spring from the secondary piston.

9 Carefully disassemble the pistons (see illustration). Don't damage the pistons as you handle them.

10 Remove the circlip from the rear reservoir opening. Tap out the fast fill valve on a piece of wood. Remove the O-ring.

11 Remove the end plug from the unit.

12 Remove the switch from the bottom of the master cylinder. Don't lose the small spring.

13 Tap the proportioning valve out of the cylinder onto a piece of wood. Don't disassemble it.

14 Inspect the cylinder bore for corrosion and damage. If any corrosion or damage is found, renew the master cylinder body with a new one, as abrasives cannot be used on the bore. If the bore is not flawless, cylinder failure will result.

15 Clean everything very thoroughly and lubricate all parts except the bore plug with brake fluid (see illustration).

16 Assemble the cylinder in the reverse order in which it was disassembled.

17 Torque the end plug to the specification in this Chapter.

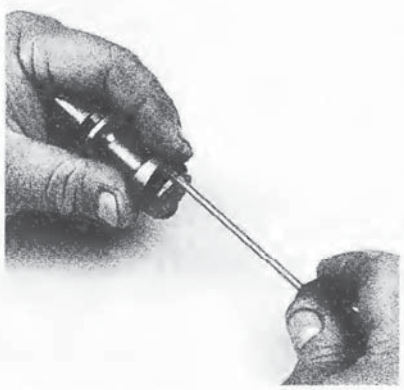
18 Anytime the master cylinder is removed, the brake hydraulic system must be bled. It's much easier to bleed the rest of the system quickly and effectively if you "bench bleed" the master cylinder before refitting it on the vehicle. Bench bleed the master cylinder as follows.

19 Insert threaded plugs of the correct size into the cylinder outlet holes and fill the reservoirs with brake fluid (the master cylinder should be supported in such a manner that brake fluid will not spill out of it during the bench bleeding procedure).

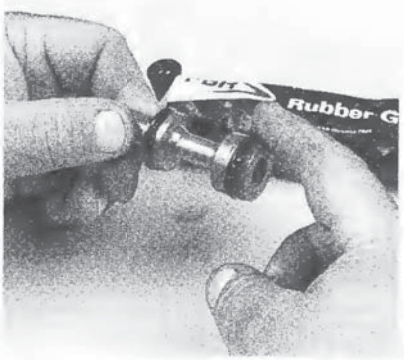
20 Loosen one plug at a time and push the piston assembly into the bore to force air from the master cylinder. To prevent air from being drawn back into the cylinder, the appropriate plug must be tightened before allowing the piston to return to its original position.

21 Stroke the piston three or four times for each outlet to assure that all air has been expelled.

6.8 Use a block of wood to tap out the secondary piston

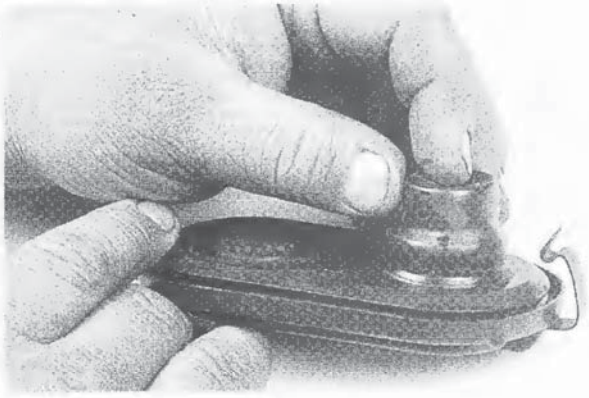


6.9 All rubber parts must be renewed



6.15 Lubricate all parts with brake fluid or approved brake system lubricant

6.22a Make sure the fluid is between the two marks



6.22b Renew the cap diaphragm if it shows signs of cracking

22 Refill the master cylinder reservoirs and refit the diaphragm and cap assembly (see illustrations).

> ***Note:*** *The reservoir should only be filled to the top of the reservoir divider to prevent overflowing when the cover and diaphragm are refitted.*

REFITTING

23 The remainder of refitting is the reverse of removal. Make sure you bleed the rest of the system when you're done (see Section 8).

7 Brake hoses and lines - inspection and renewal

INSPECTION

1 About every six months, loosen the wheel lug nuts, raise the vehicle, place it securely on jackstands, remove the wheels, and inspect the flexible hoses which connect the steel brake lines with the front and rear brake assemblies. Look for cracks, chafing, leaks, blisters and any other damage. These are important and vulnerable parts of the brake system, so your inspection should be thorough. You'll need a flashlight and mirror to do the job right. If a hose exhibits any of the above conditions, renew it as follows.

Brake hose

Refer to illustrations 7.2 and 7.3

2 Using a flare-nut spanner, disconnect the brake line from the hose fitting, being careful not to bend the frame bracket or brake line (see illustration).

3 Use pliers to remove the U-clip from the female fitting at the bracket (see illustration), then remove the hose from the bracket.

4 At the caliper end of the hose, remove the banjo bolt from the fitting block, then remove the hose and the sealing washers on each side of the fitting block.

5 When refitting the hose, always use new sealing washers on each side of the fitting block and lubricate all bolt threads with clean brake fluid before refitting them.

6 With the fitting flange engaged with the caliper locating ledge, attach the hose to the caliper and tighten it.

7 Without twisting the hose, refit the female fitting in the hose bracket (it will fit the bracket in only one position).

8 Refit the U-clip retaining the female fitting to the frame bracket.

9 Attach the brake line to the hose fitting and tighten it to the torque listed in this Chapter's Specifications.

10 When the brake hose refitting is complete, there should be no kinks in the hose. Also make sure that the hose does not contact any part of the suspension. If you're renewing a front brake hose, verify this by turning the wheels to the extreme

7.2 Using a flare-nut spanner, unscrew the brake line from the hose fitting, being careful not to bend the frame bracket or brake line

7.3 Use pliers to remove the U-clip from the female fitting at the bracket, then remove the hose from the bracket

left and right positions. If the hose contacts anything, disconnect it and correct as necessary.

11 Fill the master cylinder reservoir and bleed the system (see Section 8).

Steel brake lines

12 When it becomes necessary to renew steel lines, use only double-flared steel tubing. Never substitute copper tubing because copper is subject to fatigue cracking and corrosion as well as being much weaker. The outside diameter of the tubing is used for sizing.

13 Auto parts stores and brake supply houses carry various lengths of prefabricated brake line. Depending on the type of tubing used, these sections can either be bent by hand into the desired shape or bent in a hand tubing bender.

14 When refitting the brake line, make sure there is plenty of clearance between the line and any hot or moving parts.

8 Brake hydraulic system - bleeding

Refer to illustration 8.6

Warning 1: *Use only DOT 4 brake fluid.*

Warning 2: *Wear eye protection when bleeding the brake system. If the fluid comes in contact with your eyes, immediately rinse them with water and seek medical attention.*

Warning 3: *When any bleeding operation is done which involves the ABS hydraulic control module, a computer scan tool must be used by a properly trained shop to perform important additional procedures. This will ensure proper operation of the ABS system.*

Note: *Bleeding the brake system is necessary to remove any air that's trapped in the system when it's opened during removal and refitting of a hose, line, caliper or master cylinder.*

1 Bleeding of the hydraulic system is necessary to remove air whenever it is introduced into the brake system.

2 Have an assistant on hand, as well as a supply of new brake fluid, an empty clear container, a length of clear plastic tubing to fit over the bleeder valve and a spanner to open and close the bleeder valve.

3 Remove the cap from the brake fluid reservoir and add fluid, if necessary (see Chapter 1). Don't allow the fluid level to drop too low during this procedure - check it frequently. Reinstall the cap.

4 Raise the vehicle and support it securely on jackstands.

5 Beginning at the left rear brake, loosen the bleeder screw slightly, then tighten it to a point where it's snug but can still be loosened quickly and easily.

6 Place one end of the tubing over the bleeder screw and submerge the other end in brake fluid in the container (see illustration).

7 Open the bleeder screw and have your assistant slowly depress the brake pedal and hold the pedal firmly depressed. Watch for air bubbles to exit the submerged end of the tube. When the fluid flow slows, tighten the screw, then have your assistant slowly release the pedal. Wait five seconds before proceeding.

8 Repeat Step 7 until no more air is seen leaving the tube, then tighten the bleeder screw and proceed to the right rear brake, left front brake and right front brake, in that order. Be sure to check the fluid in the master cylinder reservoir frequently.

9 After bleeding all of the wheel brakes in the proper order, repeat Steps 6 through 8 on the left rear brake, right front brake and the left front brake, in that order.

10 Lower the vehicle and check the fluid level in the brake fluid reservoir, adding fluid as necessary.

11 Never use old brake fluid. It contains moisture which will allow the fluid to boil, rendering the brakes useless. When bleeding, make sure the fluid coming out of the bleeder is not only free of bubbles, but clean also.

12 Refill the fluid reservoir with new fluid at the end of the operation.

13 Check the operation of the brakes. The pedal should feel solid when depressed, with no sponginess. If necessary, repeat the entire process.

Warning: *Do not operate the vehicle if you are in doubt about the effectiveness of the brake system.*

9 Power brake booster - inspection, removal and refitting

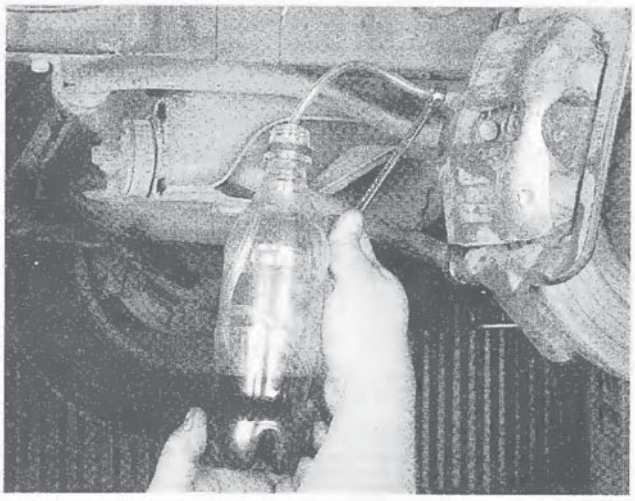
OPERATING CHECK

1 Depress the brake pedal several times with the engine off and make sure that there is no change in the pedal reserve distance.

2 Depress the pedal and start the engine. If the pedal goes down slightly, operation is normal.

AIR TIGHTNESS CHECK

3 Start the engine and turn it off after one or two minutes. Depress the brake pedal several times slowly. If the pedal goes down farther the first time but gradually rises after the second or third depression, the booster is airtight.



8.6 When bleeding the brakes, a hose is connected to the bleeder screw and then submerged in brake fluid - air will be seen as bubbles in the tube and container (all air must be expelled before moving to the next brake or component)

4 Depress the brake pedal while the engine is running, then stop the engine with the pedal depressed. If there is no change in the pedal reserve travel after holding the pedal for 30 seconds, the booster is airtight.

REMOVAL AND REFITTING

Note: The brake booster cannot be overhauled. If a problem develops, a new or factory-exchange unit must be fitted.

5 Remove the master cylinder (refer to Section 6).

Caution: Do not press on the brake pedal after the master cylinder has been removed.

6 Disconnect the vacuum hose leading to the front of the power brake booster. Cover the end of the hose.

7 Inside the vehicle, remove the instrument panel lower cover (refer to Chapter 11).

8 Disconnect the power brake pushrod from the brake pedal. Do not force the pushrod to the side when disconnecting it.

9 Remove the four booster mounting nuts and carefully lift the unit out of the engine compartment.

10 When refitting, loosely refit the four mounting nuts, then connect the pushrod to the brake pedal. Tighten the nuts to the specified torque and reconnect the vacuum hose and master cylinder. If the brake lines were disconnected from the master cylinder, bleed the brake system to eliminate any air which has entered the system (see Section 8).

10 Parking brake shoes - removal, inspection and refitting

Warning: Dust created by the brake system is harmful to your health. Never blow it out with compressed air and don't inhale any of it. An approved filtering mask should be worn when working on the brakes. Do not, under any circumstances, use petroleum-based solvents to clean brake parts. Use brake system cleaner only.

Note: Parking brake shoes should be renewed on both wheels at the same time - never renew the shoes on only one wheel.

REMOVAL

Refer to illustrations 10.4a, 10.4b, 10.4c and 10.6

Note: Disassemble only one brake at a time. The other side can then serve as a reference in case of a question about proper assembly.

1 The parking brake system should be checked as a normal part of driving. With the vehicle parked on a hill, apply the brake, place the transmission in Neutral and verify that the parking brake alone with hold the vehicle (be sure to stay in the vehicle during this check). Additionally, every 24 months - and any time a fault is suspected - the assembly itself should be visually inspected.

2 Loosen the rear wheel lug nuts, raise the rear of the vehicle and support it securely on jackstands. Block the front wheels and remove the rear wheels. Release the parking brake.

3 Remove the rear calipers (see Section 3). Support the caliper assemblies with a coat hanger or heavy wire. Don't disconnect the brake line from the caliper. Remove the caliper mounting bracket.

4 If the discs won't come off easily, remove one of the adjustment screw covers and back off the parking brake by turning the star wheel with a screwdriver (see illustrations). Remove the rear discs (see illustration).

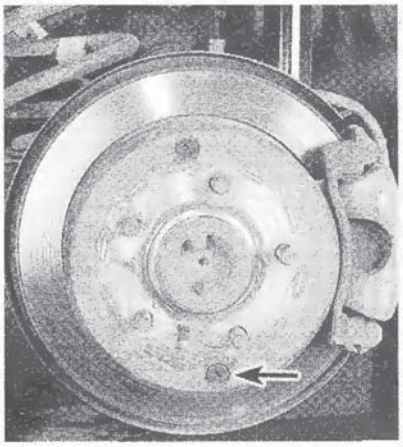
5 Clean the parking brake assembly with brake system cleaner.

6 Disconnect the shoes from the actuating assembly and the retaining clips (see illustration).

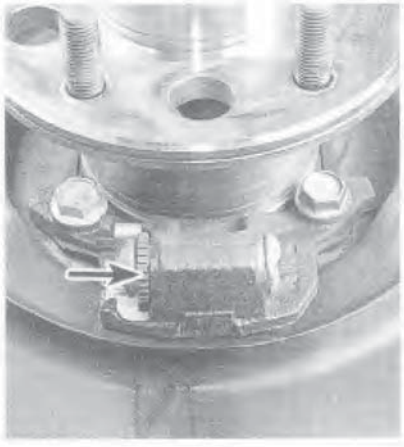
7 Remove the retaining clips. The actuating assembly cannot be removed without first removing the disc shield.

INSPECTION

8 Inspect the lining contact pattern to determine whether the shoes are bent or have been improperly adjusted. The lining should show contact across the entire width, extending from

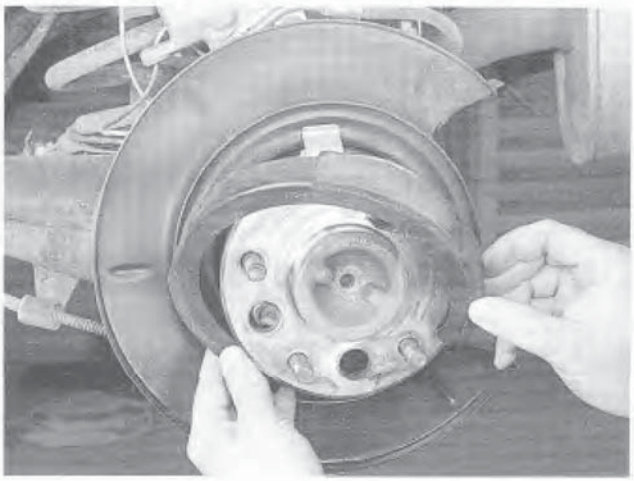


10.4a Remove one of the parking brake adjuster screw covers (arrow) ...

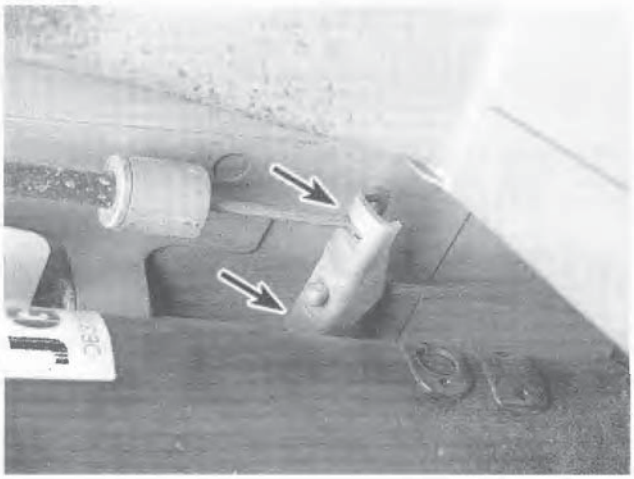


10.4b ... and use a screwdriver to turn the star wheel adjuster and back off the parking brake shoes

10.4c Remove the rear disc and parking brake drum assembly



10.6 Rotate the parking brake shoe assembly with a twisting action to remove it from the vehicle



11.8 Disconnect the cables (arrows) from the equaliser bracket

head to toe. Shoes showing contact only on one side should be renewed.

9 Clean the backing plate with brake system cleaner. Inspect all the hardware and small parts. Inspect the drum portion of the disc.

REFITTING

10 Assembly is the reverse of removal. If in doubt about any of the refitting, check the other rear wheel brake which has not been disassembled.

11 Clean all parts and lightly lubricate all wear surfaces with molybdenum disulphide grease.

12 Refit the disc. Using a screwdriver or brake adjusting tool, turn the star wheel on the parking brake shoe adjuster until the shoes slightly drag as the disc is turned, then back-off the adjuster until the shoes don't drag.

13 Repeat this sequence for the parking brake shoes at the other rear wheel.

14 Adjust the parking brake cables if necessary (refer to Section 12). Make sure that the wheels rotate freely with the parking brake released.

11 Parking brake cable - renewal

FRONT CABLE

Refer to illustration 11.8

1 Raise the vehicle and support it securely on jackstands.

2 Release the parking brake.

3 Remove the driver's seat (refer to Chapter 11).

4 Pull the parking brake lever boot up and remove the cable adjusting nut.

5 Remove the two lever assembly mounting bolts from under the carpet and lift out the lever assembly.

6 Remove the console (see Chapter 11).

7 Remove the two screws from the parking brake cable mounting bracket.

8 Working under the vehicle, disconnect the rear cables from the equalising bracket (see illustration).

9 Unbolt the other front cable mounting bracket.

> ***Note:*** *On some models, it is necessary to first remove the driveshaft to gain access to the bracket bolt.*

10 Pull the cable into the vehicle to remove it.

11 Refitting is the reverse of removal. Adjust the cable (refer to Section 12).

REAR CABLES

12 Raise the vehicle and support it securely on jackstands.

13 Release the parking brake.

14 Loosen the parking brake cable adjustment as much as possible without removing the adjusting nut (refer to Section 12).

15 Unclip the rear cable(s) from the retainers that secure it to the body.

> ***Note:*** *On some models, it is necessary to first remove the driveshaft to gain access to these retainers.*

16 Disconnect the front of the cable(s) from the equaliser bracket at the front.

17 Disconnect the cable(s) from the rear parking brake lever and remove it from the vehicle.

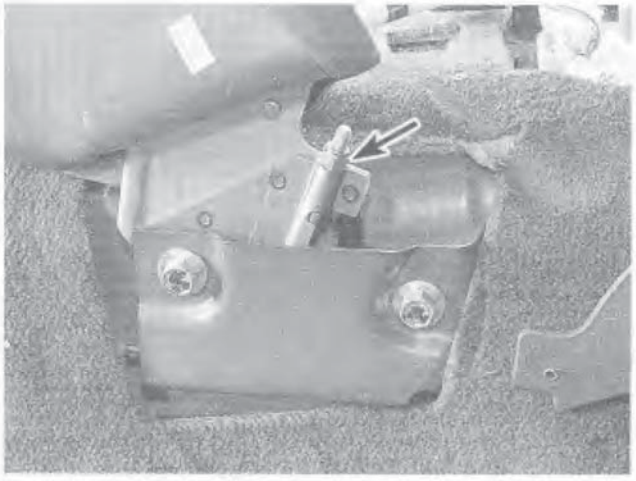
18 Refitting is the reverse of removal. Adjust the cable (refer to Section 12).

12 Parking brake - adjustment

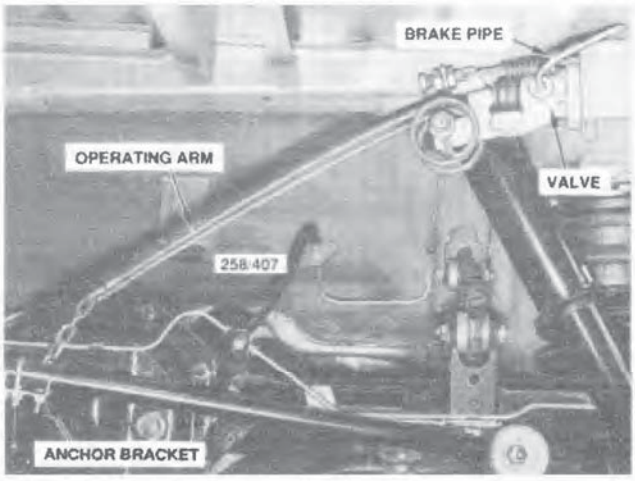
Refer to illustration 12.4

1 It's a good idea to check cable adjustment whenever a parking brake is disassembled.

2 Raise the rear of the vehicle and support it securely on jackstands.



12.4 The parking brake adjustment nut (arrow) can be found under the lever boot



14.4 Typical load sensing valve and components - (utility models only)

3 Pull back the rubber boot at the base of the parking brake cable.
4 Loosen the parking brake adjustment nut a few turns (see illustration).
5 Pull up on the lever 5 clicks.
6 Tighten the cable adjusting nut until the slack is removed and there is some resistance to further tightening (approximately 2 Nm of torque).
7 Check for correct feel of the lever operation.
8 Make sure that the rear wheels rotate with zero parking brake drag when the lever is released.
9 Remove the jackstands and lower the vehicle.

13 Brake light switch - check, renewal and adjustment

CHECK

1 The brake light switch is located on the brake pedal bracket. You'll need to remove the trim panel beneath the steering column to get to the switch and connector.
2 With the brake pedal in the fully released position, the switch plunger is pressed into the switch housing. When the brake pedal is depressed, the plunger protrudes from the switch, which closes the circuit and sends current to the brake lights.
3 If the brake lights are inoperative, check the fuse (see Chapter 12).
4 If the fuse is okay, verify that voltage is available at the switch.
5 If there's no voltage to the switch, use a test light to find the open circuit condition between the fuse panel and the switch. If there is voltage to the switch, close the switch (depress the brake pedal) and verify that there's voltage on the other side of the switch.
6 If there's no voltage on the other side of the switch with the brake pedal depressed, renew the switch (see Step 7). If voltage is available, check for voltage at the brake lights. If the no power is present, look for an open circuit condition between the switch and the brake lights.

RENEWAL

7 Remove the instrument panel lower cover.
8 Unplug the electrical connector from the switch.
9 Pull the switch out of its clip in the bracket.
10 The switch must be adjusted as it's refitted (see below).

ADJUSTMENT

11 Push the switch into its clip until there is a 6 mm gap between the switch body and the bracket.
12 You can check your work with an ohmmeter or the brake lights by verifying that the switch contacts are open at 15 mm of brake pedal travel, and closed thereafter.
13 Refitting is otherwise the reverse of removal.

14 Load sensing valve (utility models) - removal, refitting and adjustment

REMOVAL

Refer to illustration 14.4

1 Raise the rear of the vehicle and support it securely on jack stands.
2 Remove the rear wheels.
3 Disconnect the brake lines from the load sensing valve. Plug the ends of the lines to prevent loss of fluid and the entry of dirt.
4 Hold the load sensing valve operating arm towards the panhard rod and disconnect the anchor bracket from the panhard rod (see illustration). Slowly release the arm.
5 Remove the retaining bolts and remove the load sensing valve from the vehicle.

REFITTING

6 Refit the bolts mounting the load sensing valve and tighten them securely.

7 Bleed the brakes (see Section 8).

8 Adjust the valve anchor bracket as described in the following text.

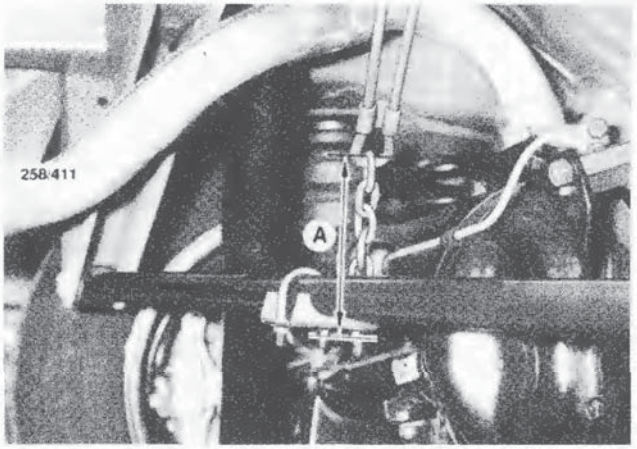
9 Refit the wheel and tighten securely. Lower the vehicle and check the fluid level in the brake fluid reservoir, adding fluid as necessary.

ADJUSTMENT

Refer to illustration 14.11

10 Locate the anchor bracket U-bolt 483 mm to the left of the panhard rod mounting bolt on the rear axle housing.

11 Adjust the anchor bolt until a distance of 116 to 117 mm exists between the upper face of the anchor bracket and the top edge of the operating arm where the chain is connected (see illustration).



14.11 Load sensing valve adjustment details, dimension A should be 116 to 117 mm

Chapter 10
Suspension and steering systems

Contents

Specifications

General

Power steering fluid type	See Chapter 1
Station wagon rear shock absorber nut-to-stud end distance	15.5 to 16.0 mm

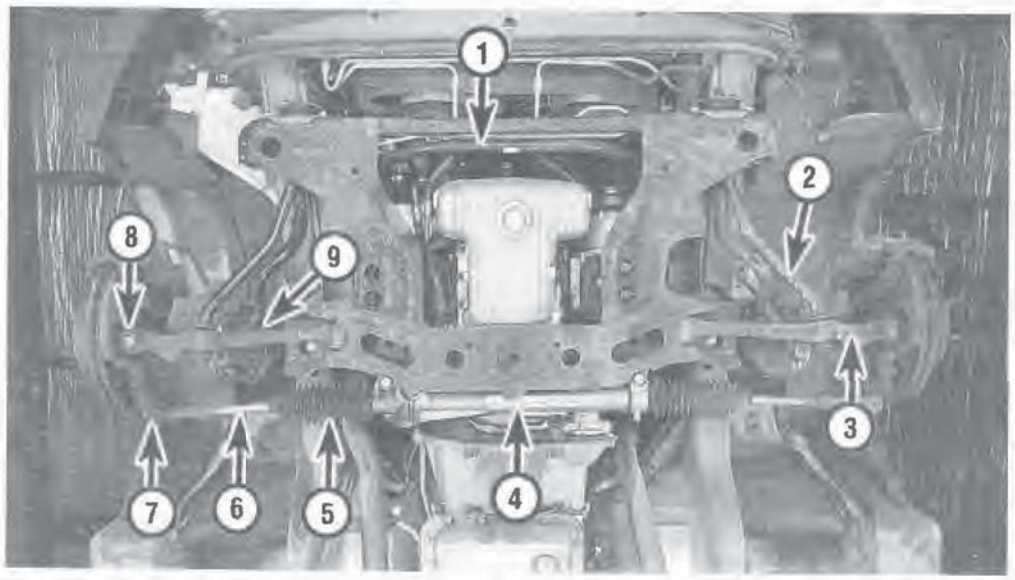
Torque specifications

	Nm
Front suspension	
Steering knuckle-to-strut bolt	
Step 1	85
Step 2	100
Step 3	Tighten an additional 90 degrees
Balljoint clamp bolt (VT Series I)	
Step 1	70
Step 2	Tighten an additional 30 to 40 degrees
Balljoint stud nut (VT Series II to VZ models)	50 to 70
Crossmember to frame bolts	120 to 125*

Torque specifications (continued)

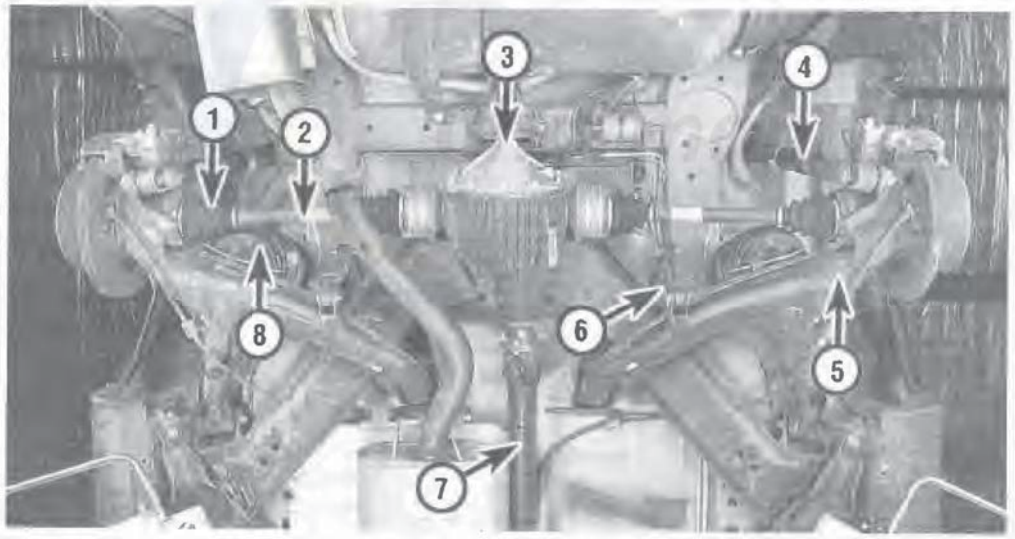
	Nm
Front suspension (continued)	
Lower control arm inner pivot bolt	
VT to VY models	95 to 100*
VZ models	103*
Shock absorber/coil spring assemblies	
Upper strut-to-body nut	50 to 60**
Upper strut bearing retaining nut	70 to 85**
Stabiliser bar clamp bolts	24 to 30
Tension rod nuts	
Front	140 to 155*
Rear	95 to 110*
Hydraulic strut damper nuts	20 to 26
Rear suspension	
Lower control arm bolts	95 to 105
Shock absorber	
Station wagon upper shock absorber mounting plate bolts	42 to 50
Lower nuts (all)	105 to 125
Stabiliser bar	
Link-to-control arm nut	90 to 105
Clamp bolts	18 to 26
Steering	
Steering gear-to-crossmember bolts	
VT models	50 to 85
VZ models	
Step 1	60
Step 2	Tighten an additional 40 to 50 degrees
Power steering pump bolts/nuts	
3.8 litre V6 models	30 to 40
3.6 litre V6 models	20 to 35
5.0 litre V8 models	35 to 65
5.7 litre Gen III V8 and 6.0 litre Gen IV V8	20 to 35
Front hub bolts	100 to 115
Tie-rod end castle nuts	50 to 85
Steering shaft U-joint coupling bolt/nut	23 to 30
Steering wheel bolt	40 to 50
Horn pad and airbag module screws (VT and VX models)	10 to 14

** New bolts must be used on VY and VZ models*
*** New bolts must be used on all models*



1.1 Typical front suspension and steering layout

1 *Stabiliser bar*
2 *Tension rod*
3 *Lower control arm*
4 *Steering gear assembly*
5 *Steering gear boot*
6 *Tie-rod*
7 *Tie-rod end*
8 *Balljoint*
9 *Strut/coil spring*



1.2 Typical rear suspension layout

1 *Outer CV joint*
2 *Driveaxle*
3 *Final drive unit*
4 *Shock absorber*
5 *Control arm*
6 *Stabiliser bar link*
7 *Driveshaft*
8 *Coil spring*

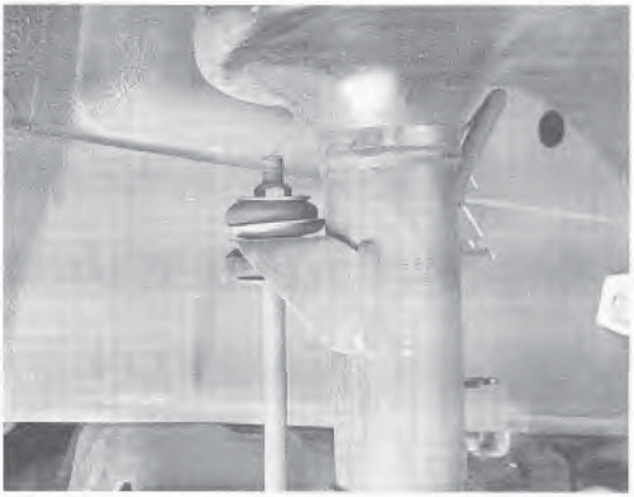
1 General information

SUSPENSION

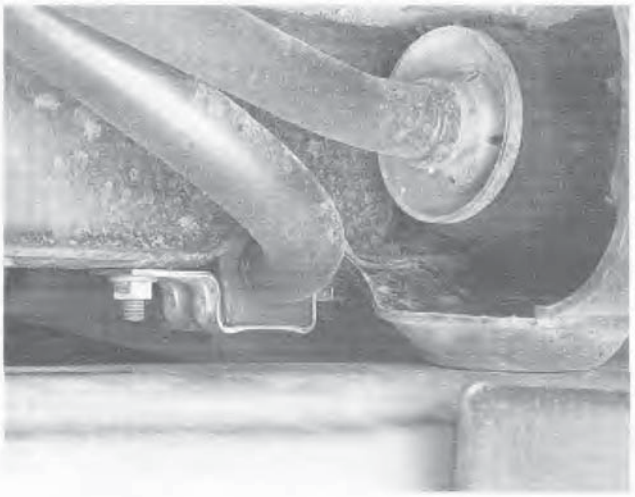
Refer to illustrations 1.1 and 1.2

1 The fully-independent front suspension used on these models allows each wheel to compensate for road surface irregularities without any appreciable effect on the other wheel (see illustration). The suspension at each front wheel consists of a MacPherson strut, a lower control arm and a tension rod. The lower balljoints are pressed into the lower control arms. A stabiliser bar controls vehicle roll during cornering. The stabiliser bar is attached to the frame by a pair of steel clamps and to the lower control arms by link bolts.

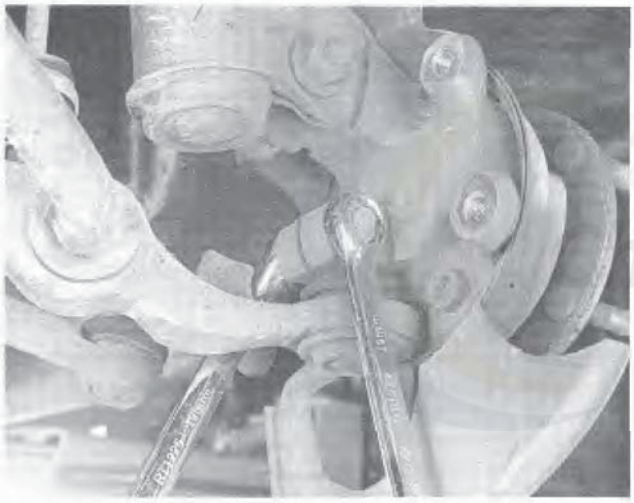
2 These models have a fully-independent rear suspension system (see illustration). This consists of two trailing control arms, coil springs and shock absorbers.



2.2 Disconnect the front stabiliser bar links where they attach to each suspension strut



2.3 To detach the stabiliser bar from the frame, remove the bolts and nuts from both bush clamps - make sure the slit in the bush faces forward when you refit the stabiliser bar



3.3 Use two spanners to remove the balljoint clamp bolt and nut

STEERING

3 The steering system (see illustration 1.1) consists of a rack-and-pinion type steering gear connected to the steering knuckles by adjustable tie-rods.

2 Stabiliser bar (front) - removal and refitting

Refer to illustrations 2.2 and 2.3

1 Raise the vehicle and support it securely on jackstands.

2 Remove the nuts, bushes and sleeves from the link bolts that attach each end of the stabiliser bar to the suspension strut (see illustration). Note the order in which the bushes and sleeves are removed to ensure proper reassembly.

3 Remove the stabiliser bar clamps and rubber bushes (see illustration).

4 Remove the stabiliser bar. Make a note of which side goes on each side of the vehicle.

5 Inspect the rubber bushes and link bolt grommets for cracks and tears. Renew all damaged bushes and grommets.

6 Apply multi-purpose grease to the bush areas on the stabiliser bar before refitting the bushes and clamps.

7 Make sure the slits in the mounting bushes face the front of the car.

8 Make sure the stabiliser bar is centred in the bushes and clamps before tightening the mounting bolts.

9 Refitting is otherwise the reverse of the removal procedure. Be sure to tighten all bolts to the torques listed in this Chapter's Specifications. Don't overstress the rubber bushes.

3 Lower control arm (front) - removal and refitting

Refer to illustrations 3.3, 3.6 and 3.7

1 Loosen the wheel lug nuts, raise the vehicle and place it securely on jackstands. Remove the wheel.

2 Remove the brake caliper (see Chapter 9) and hang it out of the way.

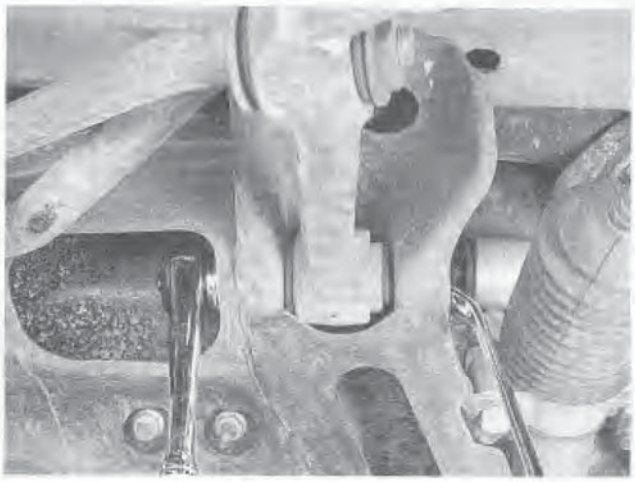
3 On VT Series I models, remove the balljoint clamp nut and bolt (see illustration). On all other models, remove the balljoint stud nut and, using a commercially available balljoint separator, separate the balljoint stud from the steering knuckle.

> ***Note:*** *The thread of the balljoint stud is easily damaged by the balljoint separator. If damaged, the balljoint will have to be renewed.*

4 Remove the tension strut nut and washer from the lower control arm.

5 Loosen the tension strut-to-hydraulic damper nut. Remove the four damper unit-to-chassis nuts, then detach the tension rod from the lower control arm.

3.6 To separate the lower control arm from the steering knuckle, insert a lever between the control arm and the knuckle as shown



3.7 To detach the control arm from the crossmember, remove the nut and bolt using two spanners

6 Remove the balljoint clamp bolt and prise the lower arm down (see illustration).

7 Remove the nut and bolt that attaches the lower control arm to the crossmember (see illustration).

8 Remove the lower control arm.

9 Inspect the control arm for cracking or damage.

10 Inspect the bush in the lower control arm. If the bush is torn or cracked, take the control arm to an automotive machine shop and have the old bush pressed out and a new bush pressed in.

11 Refitting is the reverse of the removal procedure. Use new self-locking nuts on both ends of the tension strut and the balljoint clamp bolt. The tension strut nuts and inner lower control arm nut and bolt must be fully tightened to the torque listed in this Chapter's Specifications, after the vehicle is lowered to the ground and bounced a few times.

4 Tension rod - removal and refitting

Refer to illustration 4.3

1 Loosen the wheel lug nuts, raise the front of the vehicle, support it securely on jackstands and remove the wheel.

2 Remove the lower control arm balljoint clamp bolt and nut (see Section 3).

3 Remove the tension rod-to-lower control arm nut and washer (see illustration).

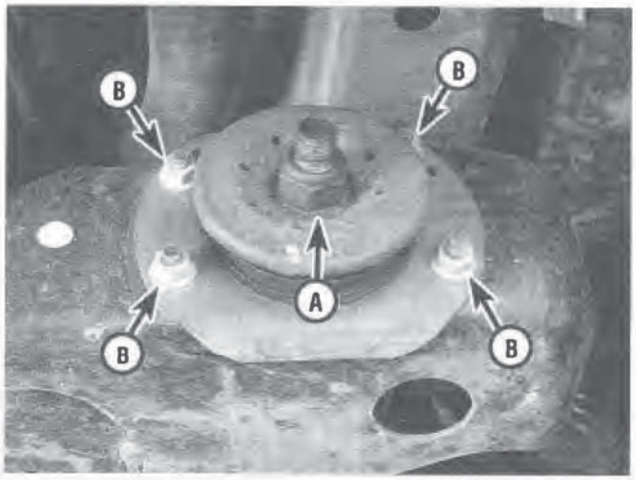
4 Remove the four tension rod hydraulic damper nuts and detach the tension rod from the lower suspension arm (see Section 5).

5 Slide the hydraulic damper and tension rod assembly out of the chassis crossmember and remove it from the vehicle.

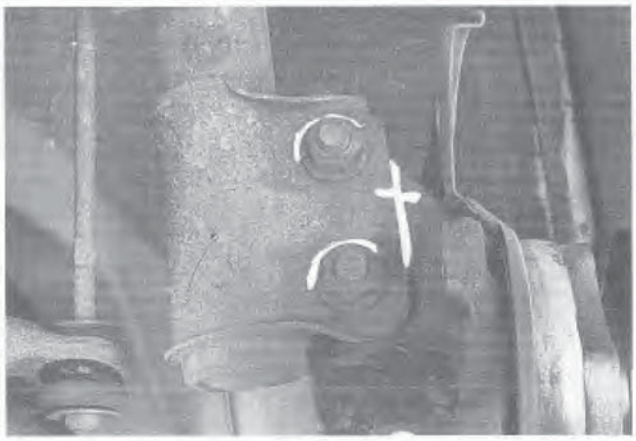
6 Mount the assembly in a padded vice, remove the strut rod nut and separate it from the damper assembly.

7 Refitting is the reverse of removal. Fit new self-locking nuts on the tension rod and balljoint clamp bolt.

4.3 Remove the tension rod nut and washer (arrow) from the lower control arm



5.1 Remove the tension rod nut and washer (A), followed by the four tension rod damper nuts (B)



6.6 Mark the strut-to-steering knuckle relationship, then remove the bolts

8 The tension rod nuts must be fully tightened to the torque listed in the Specifications Section, after the vehicle is lowered to the ground and bounced a few times.

5 Tension rod damper - removal and refitting

Refer to illustration 5.1

1 Remove the large self-locking nut retaining the tension rod to the damper, then remove the four nuts securing the damper to the crossmember (see illustration).
2 Detach the damper from the vehicle.
3 Refitting is the reverse of removal, using a new self-locking nut on the tension rod. The tension rod nuts must be fully tightened to the torque listed in the Specifications Section, after the vehicle is lowered to the ground and bounced a few times.

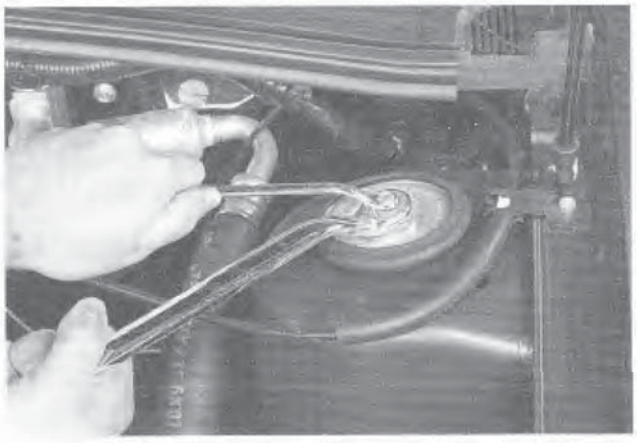
6 MacPherson strut assembly - removal and refitting

Refer to illustrations 6.6 and 6.8

1 Raise the front of the vehicle and support it on jackstands.
2 Remove the wheel.
3 Disconnect the stabiliser bar from the suspension strut (see Section 2).
4 Remove the brake disc as described in Chapter 9.
5 Remove the brake hose from the strut by turning the plastic sleeve on the hose so that the flats on the sleeve coincide with the hole in the bracket. Tie the caliper out of the way.

> ***Note:*** *Some models may have a clip retaining the brake hose to the strut. On these models, slide the clip from between the hose and strut with a screwdriver, then separate the hose from the strut.*

6 Under the vehicle, mark the strut-to-steering knuckle relationship, then remove the mounting nuts and bolts (see illustration).
7 Detach the steering knuckle from the strut.
8 Remove the upper strut-to-body mounting nut, located under the bonnet (see illustration). Hold the strut shaft from moving with a 10 mm socket and use a 24 mm ring spanner to remove the nut. Remove the strut.



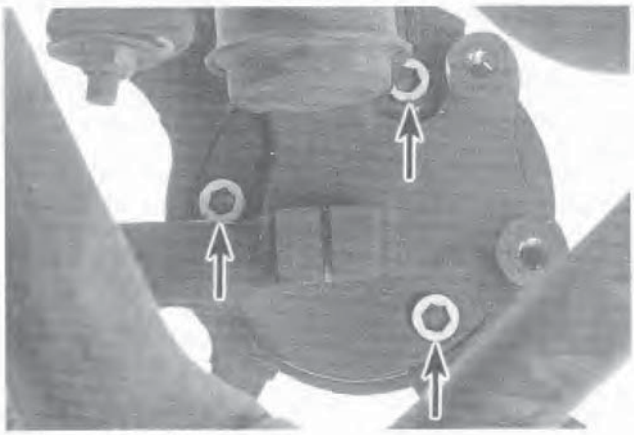
6.8 Remove the strut retaining nut (arrow) while holding the shaft from turning

9 If the strut components need to be disassembled, refer to Section 8.
10 Refitting is the reverse of the removal procedure. Refit nuts at the stabiliser bar and upper strut-to-body connections and new lower steering knuckle bolts and nuts. If the strut has been disassembled, make sure the strut bearing nut has been tightened to the figure listed in the Specifications Section. Be sure that the brake hose is not twisted and will not rub on any other parts.

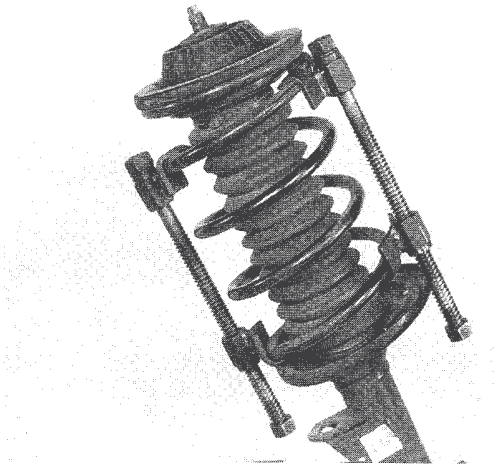
7 Front hub and bearing assembly - removal and refitting

Refer to illustration 7.4

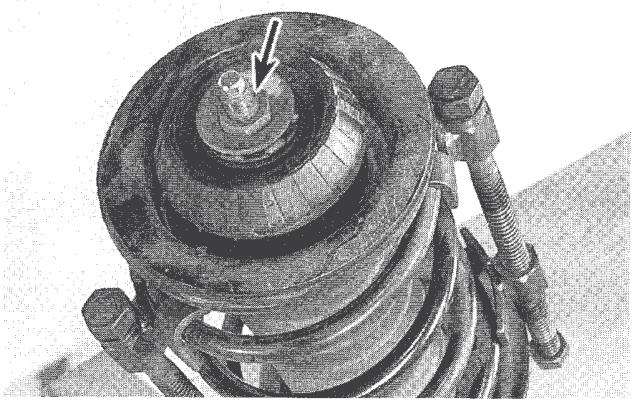
1 Loosen the front wheel lug nuts, raise the vehicle and place it securely on jackstands. Remove the wheel.
2 Remove the brake caliper and disc (see Chapter 9)
3 Unplug the ABS wheel speed sensor (if equipped).
4 Remove the Allen bolts that attach the hub to the steering knuckle (see illustration).



7.4 Remove the Allen head bolts (arrows) and detach the hub and bearing assembly from the steering knuckle

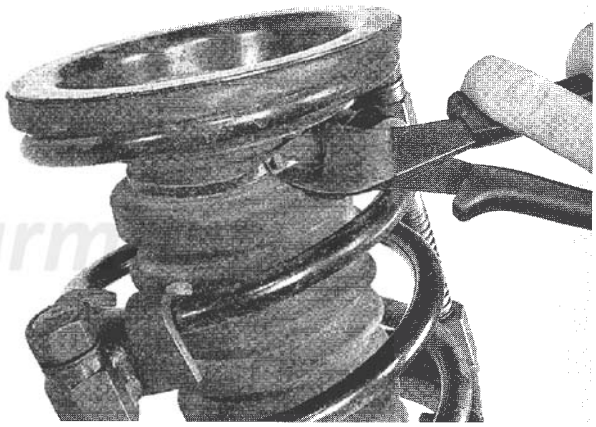


8.4 Use the spring compressor following the manufacturer's directions



8.6 Remove the nut and washer (arrow) from the strut shaft

8.7 Lift the upper strut support off of the damper shaft



8.8 Cut the plastic dust boot retainer

5 Remove the hub assembly.

6 Refitting is the reverse of removal. Tighten the hub retaining bolts to the torque listed in this Chapter's Specifications.

8 Spring and strut components (front) - disassembly and reassembly

Refer to illustrations 8.4, 8.6, 8.7, 8.8, 8.9, 8.14a, 8.14b, 8.15 and 8.16

1 The spring on the front strut is under considerable pressure, requiring a special spring compressor to be used to safely compress the spring and disengage its components. Do not attempt to disassemble the spring without the proper compressor, as serious injury can occur.

2 A strut spring compressor can be purchased through most auto parts stores. Compressors can also be rented on a daily basis from some rental agencies.

3 Hold the knuckle in a vice using wood blocks to cushion the jaws to prevent damage to it.

4 Following the manufacturer's instructions for the particular spring compressor being used, slightly compress the spring, making sure that the jaws of the compressor are firmly seated around the coils and cannot slip off (see illustration).

5 Tighten the compressor from side to side, a little at a time, until the spring seat is clear of the uppermost coil.

6 With the spring firmly compressed and clear of its seat, hold the mounting insulator stationary and remove the top strut bearing nut and washer (see illustration).

7 Pull the upper support off the top of the strut assembly (see illustration).

8 Remove the bearing (noting it's orientation) and washers and cut the dust boot strap (see illustration).

9 Carefully lift the compressed spring from the assembly (see illustration) and set it aside in a safe place.

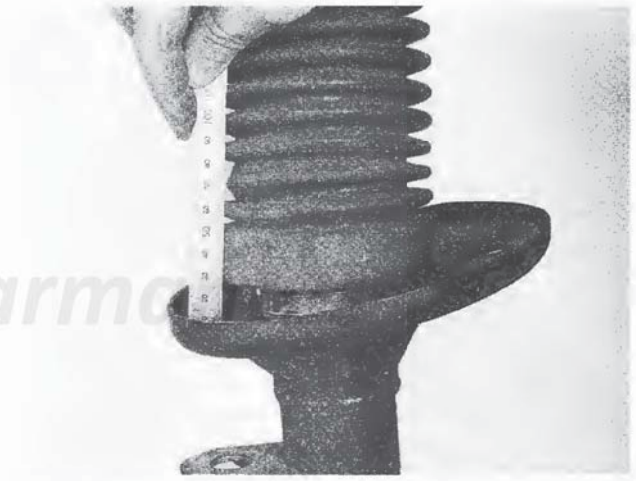
Warning: *Never place your head near the ends of the spring.*

10 The spring should be checked for cracking or deformation of any kind. If the vehicle was sagging in the front, this is an indication that the springs are in need of renewal.

8.9 The spring and compressors can be lifted off the assembly

8.14a Loosen the dust boot clamp with a screwdriver ...

8.14b ... and remove the dust boot and filter from the strut



8.15 The dust boot should fit securely on the strut and the lower edge should be the specified distance from the base of the spring mount

11 To test the shock absorber, hold it in an upright position and work the piston rod up and down its full length of travel, four or five times. If you can feel a strong resistance because of hydraulic pressure, the shock absorber is functioning properly. If you feel no marked resistance or if there is a sudden free movement in travel, the shock absorber should be renewed.

12 If there are excessive amounts of fluid evident on the outside of the shock absorber, the shock absorber should be renewed.

13 If the shock absorber is defective, obtain a new unit from a dealer or parts store.

14 Detach the clamp and remove the dust boot and filter assembly from the defective shock body (see illustrations).

15 With the strut rod of the new shock absorber all the way out, refit the dust boot/filter assembly and clamp so the boot lower edge is 30 to 35 mm from the spring mount base (see illustration).

16 With the shock absorber unit mounted in a vice with protective wood blocks, refit the spring over the shock absorber body. Make sure the lower coil conforms to the spring seat (see illustration).

8.16 When refitting the spring, make sure that the end engages in the lower seat like this

17 Refit the upper strut support bearing.
18 Refit the upper strut support.
19 Refit the washer and a new locknut to the top of the piston rod. Tighten this nut to its proper torque setting.
20 Carefully relieve tension on the coil spring by loosening the compressor from side to side, a little at a time. Check to be sure the top of the spring is raised properly into its seat.

9 Balljoints - check and renewal

CHECK

1 Inspect the control arm balljoints for looseness whenever either of them is separated from the steering knuckle. See if you can turn the ballstud in its socket with your fingers.
2 If the balljoint is loose, or if the ballstud can be turned, renew the balljoint. You can also check the balljoints with the suspension assembled as follows.
3 Raise the front of the vehicle and support it securely on jackstands placed under the chassis. Make sure the vehicle is stable. It should not rock on the stands.
4 Wipe each balljoint clean and inspect the seal for cuts and tears. If the seal is damaged, renew the balljoint.
5 To check the balljoint, grasp the top and bottom of the tyre and rock it in-and-out. If there is any up-and-down movement of the balljoint stud, renew the lower balljoint.

RENEWAL

6 Remove the control arm (see Section 3).
7 To renew the balljoint, take the control arm and a new balljoint to an automotive machine shop. The machine shop will press out the old balljoint and press in the new unit. You cannot do this at home unless you have a hydraulic press.
8 Refit the control arm.
9 Have the front end alignment checked by a dealer service department or alignment shop.

10 Shock absorbers (rear) - removal, inspection and refitting

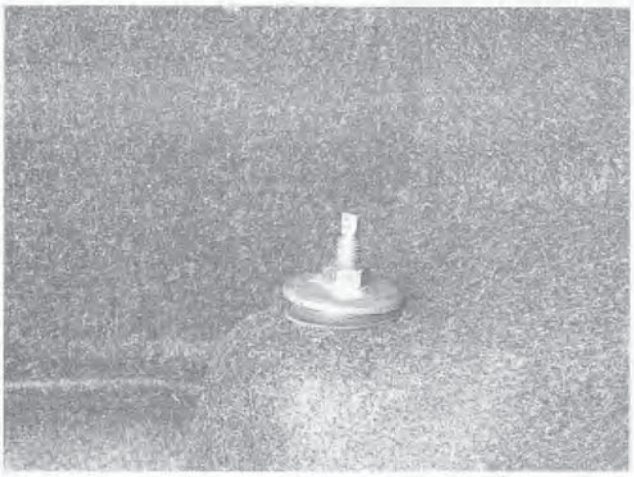
REMOVAL

Refer to illustrations 10.1 and 10.3

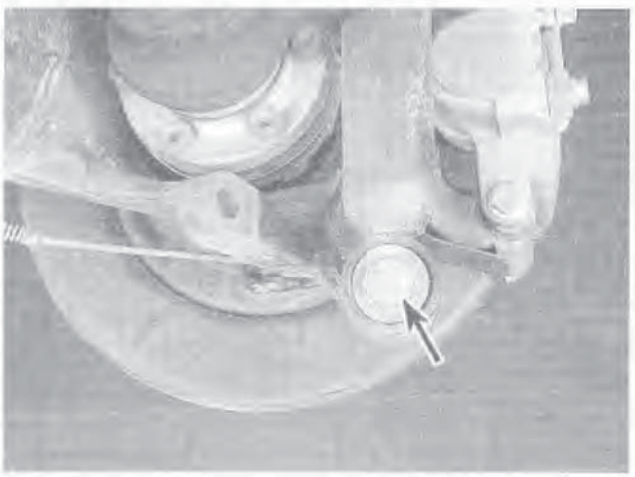
1 On sedan models, open the luggage compartment, remove any trim which would interfere with access and remove the cover and upper shock absorber nut (see illustration).
2 Raise the vehicle and support it securely on jackstands. Support the control arm with a floor jack to prevent it from dropping down when the shock absorber is disconnected.
3 On sedan and station wagon models, remove the lower shock absorber attaching bolt and remove the shock absorber from the vehicle (see illustration). On station wagon models, remove the three bolts and detach the upper shock absorber mount, then remove the upper shock nut and detach the mount.

REFITTING

4 Place the shock absorber in position on the hub and refit the bolt finger tight. Make sure the bushes and washers are refitted in the correct order.
5 On sedan models, feed the upper stud of the shock absorber through the body. Refit the nut and tighten it by hand until it is fully refitted on the stud threads.
6 On station wagon models, insert the upper stud through the shock mount opening and refit the nut. Tighten the nut until the measurement from the top of the nut to the end of the stud is as listed in the Specifications Section. Refit the upper shock absorber mount and tighten the bolts to the figure listed in the Specifications Section.
7 Tighten the lower shock absorber bolt to the figure listed in this Chapter's Specifications.
8 Lower the vehicle weight onto the suspension and tighten the upper nut to the torque listed in this Chapter's Specifications.
9 On sedan models, refit the cover and trim.



10.1 The upper shock absorber attachment is inside the luggage compartment on sedan models



10.3 Remove the lower shock absorber bolt (arrow)

SUPERLIFT SHOCK ABSORBERS

Note 1: Optional shock absorbers with built in pressurised air bags assisting the springs are installed on some models. The airbags in both shock absorbers are inflated from a common tee valve, the pressure depending on the load of the vehicle. The valve assembly is situated at the rear of the vehicle.

Note 2: Pressure in the shock absorber air bags should not exceed 1,034 kPa and not be below 103 kPa. Do not operate the vehicle in a lightly laden condition with the air bags inflated to 1,034 kPa.

Removal

Refer to illustration 10.10

10 Loosen the inflation pipe at the shock absorber and let the air escape (see illustration).

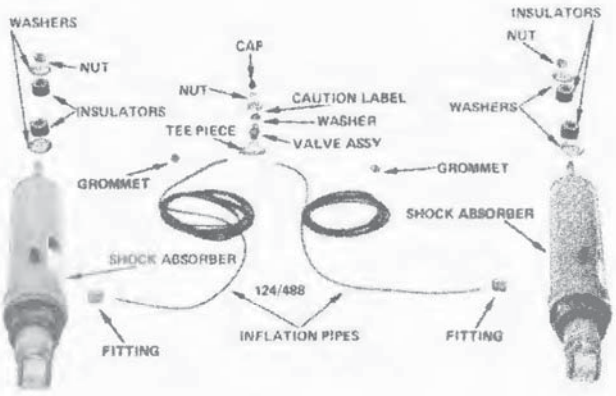
11 Remove the fitting and the inflation pipe from the shock absorber and remove the shock absorber from the vehicle as previously described in Steps 1 through 3.

Refitting

12 Install the shock absorber as described in Steps 4 through 8.

13 Connect the inflation pipe and tighten the fittings securely.

14 Inflate the shock absorber air bags to 1,034 kPa and check for leaks, using soapy water applied around all the air fittings.



10.10 Typical exploded view of the Superlift rear shock absorber components

11 Coil spring (rear) - removal and refitting

Refer to illustrations 11.5 and 11.6

1 Raise the rear of the vehicle and support it securely on jackstands.

2 Remove the wheels.

3 Disconnect the CV joint from the outer hub. Refer to Chapter 8. Support the driveshaft with wire so as not to damage the boots.

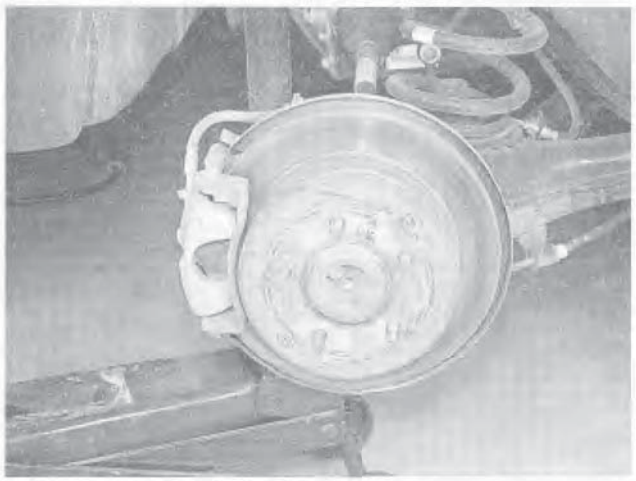
4 Disconnect the stabiliser bar from the control arm.

5 Support the control arm with a floor jack (see illustration), then disconnect the shock absorber from the control arm (see Section 10).

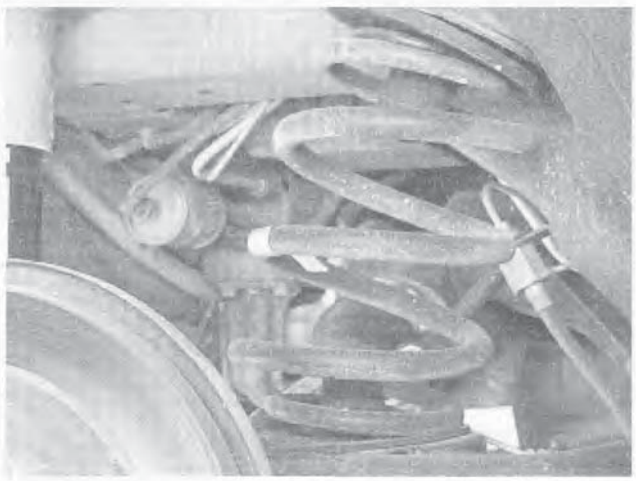
6 Slowly lower the jack until the spring is extended. The control arm can now be pushed downward to remove the spring (see illustration).

7 Check the spring for deep nicks and corrosion, which will cause premature failure of the spring. Renew the spring if these or any other questionable conditions are evident.

8 Refitting is the reverse of removal. Tighten all fasteners to the torque listed in this Chapter's Specifications.



11.5 Put a floor jack under the rear of the control arm before removing the shock absorber



11.6 The rear spring can be removed after the control arm is lowered

12.8a The rear suspension front control arm nut ...

12.8b ... and rear nut

12 Suspension arms (rear) - removal and refitting

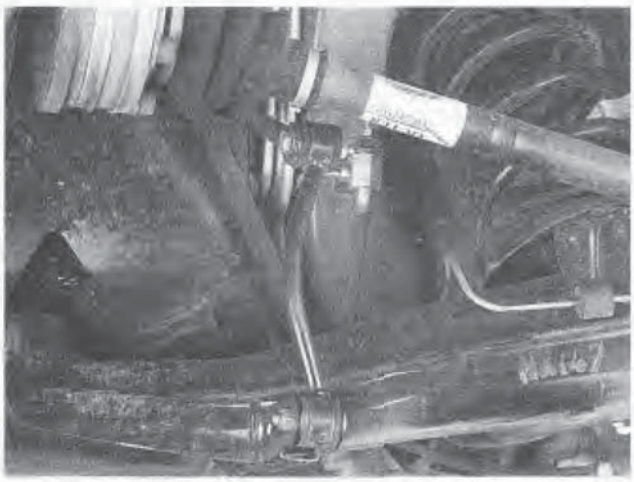
Refer to illustrations 12.8a and 12.8b

1 Raise the rear of the vehicle and support it securely on jackstands.
2 Remove the spring (refer to Section 11).
3 Unclip the brake hose from the control arm.
4 Disconnect the caliper brake hose from the brake tube. Disconnect the tube from the bracket on the caliper.
5 Refer to Chapter 9 and remove the brake caliper and the disc.
6 Refer to Chapter 8 and disconnect the driveaxle from the outer hub. Support the driveaxle with wire so as not to strain the boots.
7 Disconnect the parking brake cable from the brake actuator and the control arm.
8 Remove the pivot bolts from the crossmember (see illustrations). Remove the control arm. Further service requires special tools. Take the removed unit to a dealer or an automotive machine shop.
9 Refitting is the reverse of removal. Refer to Chapter 9 for the brake bleeding procedure.

13 Stabiliser bar (rear) - removal and refitting

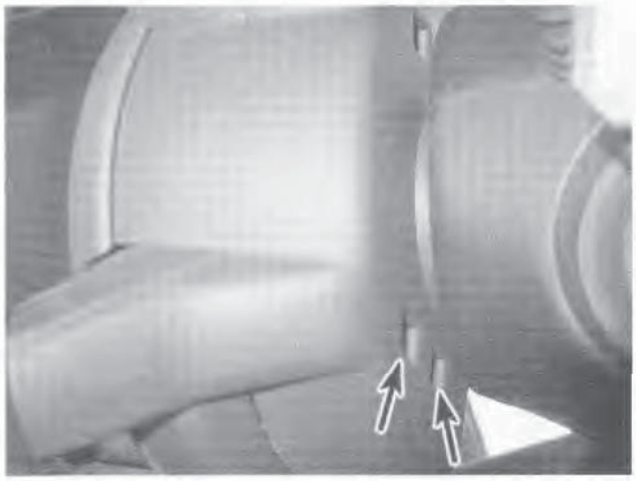
Refer to illustration 13.4

1 Raise the vehicle and support the rear axle housing securely on jackstands.
2 Put a floor jack under the differential unit.
3 Mark the position of the crossmember where it bolts to the body, then remove the bolts that secure it.
4 Lower the rear of the crossmember just enough to allow access to the stabiliser bar fasteners (see illustration).
5 Remove the stabiliser bar.

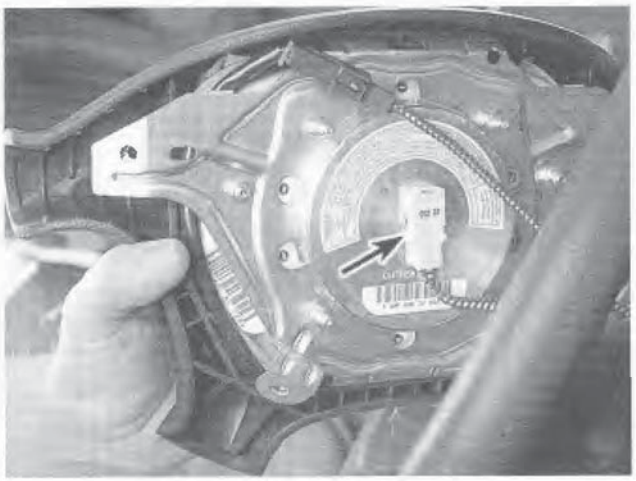


13.4 The rear stabiliser bar links are of a different design than those used on the front

14.3a On VX Series II and earlier models, use T30 Torx bit to remove the horn pad. See Chapter 12 and disable the SRS system BEFORE attempting this



14.3b On VY and later models, rotate the steering wheel 90-degrees from the straight ahead position to expose the first two access holes, then rotate the steering wheel another 180-degrees to expose the remaining two access holes



14.3c The yellow wiring connector (arrow) activates the SRS air bag system

Note: *Renewal of the stabiliser bar bushes requires the use of a hydraulic press. Take the entire bar assembly to a competent repair shop for this procedure.*

6 Before refitting the stabiliser bar, apply multi-purpose grease to the bush mounting points on the bar, then refit the bushes and clamps. Make sure the slits in the bushes face toward the front of the vehicle. Make sure the stabiliser is centred in the clamps before tightening the mounting bolts.

7 Refitting is otherwise the reverse of removal. Tighten all fasteners to the torque listed in this Chapter's Specifications. Renew the independent suspension crossmember-to-body bolts with new ones.

14 Steering wheel - removal and refitting

Refer to illustrations 14.3a, 14.3b, 14.3c, 14.5 and 14.6

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by a notice on the driver's door and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires.*

Caution: *Whenever the battery is disconnected or a power failure occurs, the radio will not operate until the owner's personal PIN number is entered. Make sure you have the correct PIN number before disconnecting the battery. See the information at the front of this manual for the radio re-activation procedure.*

1 Disconnect the cable from the negative battery terminal.

2 Disable the airbag system. See Chapter 12. Make sure the front wheels are pointed straight ahead.

3 On VX Series II and earlier models, remove the horn pad and airbag screws from the rear of the steering wheel using a T30 Torx bit (see illustration). On VY and later models, rotate the steering wheel 90 degrees from the straight ahead position and insert the special tool (Tool # AU 595) to release the retaining clips. Rotate the steering wheel 180 degrees to gain access to the two remaining access holes and insert the special tool into the holes, releasing the clips (see illustration). Lift off the horn pad and airbag module assembly and disconnect the yellow air bag wire (see illustration). Disconnect the horn wire.

Warning: *Be extremely careful when handling the removed airbag module. Do not carry it with the trim side facing your body. Store it with the trim side facing up. Do not carry it by the wiring.*

4 Disconnect the wiring. If there is sound system wiring in the steering wheel, be very careful to avoid damaging the wires.

5 Remove the bolt from the steering shaft, using a T20 Torx bit (see illustration).

14.5 Remove the steering wheel bolt (arrow), using the special Torx bit

14.6 After removing the steering wheel bolt, use a marking pen to mark the relationship of the steering wheel to the steering shaft

15.2a Loosen the tie rod lock nut...

6 Mark the end of the shaft and the steering wheel hub with a marking pen so it can be refitted correctly (see illustration).

7 Remove the steering wheel and carefully push the clock spring wires and connectors back through the hole in the wheel. After the wheel is removed, make sure the green tang is securely engaged in the inner clock spring assembly, locking it in the centralised position.

8 Refitting is the reverse of removal, taking care not to pinch any wires when installing the VY and later models.

> ***Warning:*** *On VY and later models, press the airbag module firmly into the mounting clips, but DO NOT HIT the module.*

Prior to refitting, clean the threads of the steering wheel bolt, then apply thread-locking compound to them. Be sure to tighten the steering wheel bolt to the torque listed in this Chapter's Specifications.

15 Tie-rod ends - removal and refitting

Refer to illustrations 15.2a, 15.2b and 15.3

1 Loosen the wheel lug nuts, raise the vehicle and place it securely on jackstands. Remove the wheel.

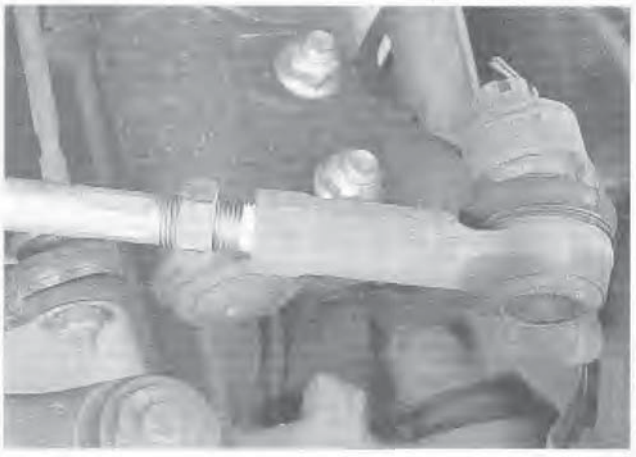
2 Loosen the tie-rod end locknut and mark the position of the tie-rod end on the threaded portion of the tie-rod (see illustrations).

3 Remove the split pin and loosen the castle nut from the tie-rod end balljoint stud, then refit a small puller (see illustration) and separate the tie-rod end from the steering knuckle. Remove the nut and detach the tie-rod end from the steering knuckle arm.

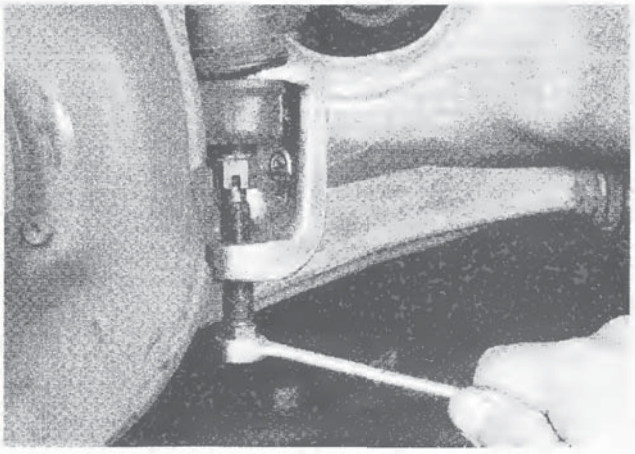
4 Unscrew the old tie-rod end and fit the new one. Make sure the new tie-rod end is aligned with the mark you made on the threads of the tie-rod.

5 Refitting is the reverse of removal. Be sure to tighten the tie-rod end balljoint nut to the torque listed in this Chapter's Specifications. Tighten the locknut securely.

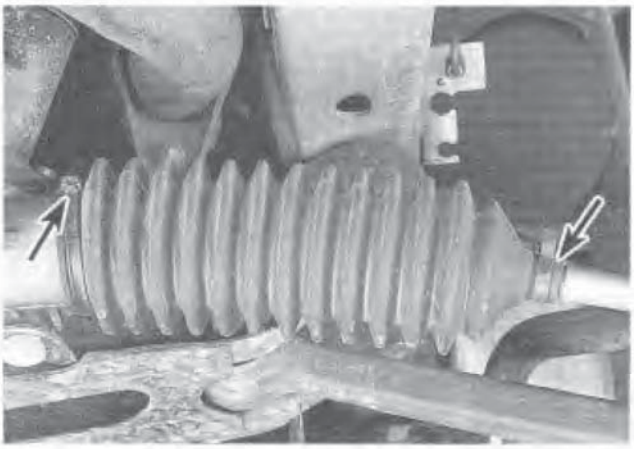
6 Have the wheel alignment toe-in checked and adjusted as necessary.



15.2b ...then mark the position of the tie-rod in relation to the threads



15.3 Disconnect the tie-rod from the steering knuckle using a special puller



16.3 Loosen these clamps (arrows) to slide the boot off of the tie-rod

16 Steering gear boots - renewal

Refer to illustration 16.3

1 If a steering gear boot is torn, dirt and moisture can damage the steering gear. Renew it.
2 Disconnect the tie-rod ends from the steering knuckles and remove them from the tie-rods (see Section 15).
3 Remove the boot clamps (see illustration) and slide the boots off the tie-rods.
4 Refitting is the reverse of removal. Be sure to use new clamps on the boots.

17 Steering gear - removal and refitting

Refer to illustrations 17.5 and 17.6

Warning: *Do not allow the steering column to rotate while the steering gear is removed; damage to the airbag contact assembly could occur. To prevent the steering column from turning, pass the seat belt through the steering wheel and clip it into place.*

1 Park the vehicle with the wheels pointing straight ahead. Disconnect the cable from the negative battery terminal.
2 Loosen the wheel lug nuts, raise the vehicle and place it securely on jackstands under the chassis. Remove the front wheels.
3 Disconnect the tie-rod ends from the steering knuckles (see Section 15).
4 Place a drain pan under the steering gear, then disconnect the pressure and return hoses attached to the power steering gear assembly. Plug the ends of the disconnected hoses and the holes in the power steering housing to prevent contamination.
5 Make an alignment mark on the steering shaft and the clamp (see illustration). Remove the pinch bolt from the steering shaft clamp.
6 Remove the nuts and bolts securing the steering gear to the crossmember (see illustration).
7 Remove the steering gear.
8 Refitting is the reverse of removal. Be sure to tighten all fasteners to the torque listed in this Chapter's Specifications.

Note: *If you're fitting a new steering gear, be sure to centre the rack in the steering gear housing before refitting.*

9 Top up the power steering pump reservoir when you're done and bleed the power steering system (see Section 19).
10 Check the front wheel alignment toe-in if necessary.

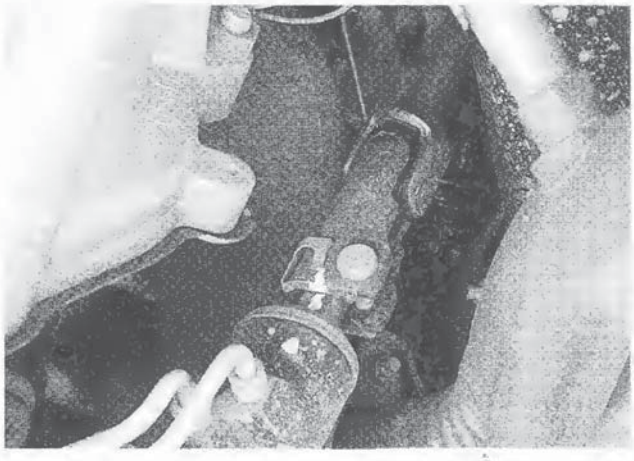
18 Power steering pump - removal and refitting

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

V6 MODELS

2 On 3.8 litre V6 models, loosen, but do not remove, the pump pulley bolts.



17.5 Mark the steering shaft and the clamp with paint before removing the pinch bolt

17.6 Remove the bolts and nuts that secure the steering rack to the crossmember

3 Remove the drivebelt (see Chapter 1).
4 Remove the pump bolts and pulley.
5 Detach the inlet and outlet hoses from the power steering pump.
6 Remove the power steering pump bolts. If necessary, remove the bolts holding the bracket to the engine, then remove the bracket.
7 Remove the pump.
8 Refitting is the reverse of removal. Renew the O-ring on the supply line fitting and lubricate it with power steering fluid before refitting. Tighten the pump bolts securely.

V8 MODELS

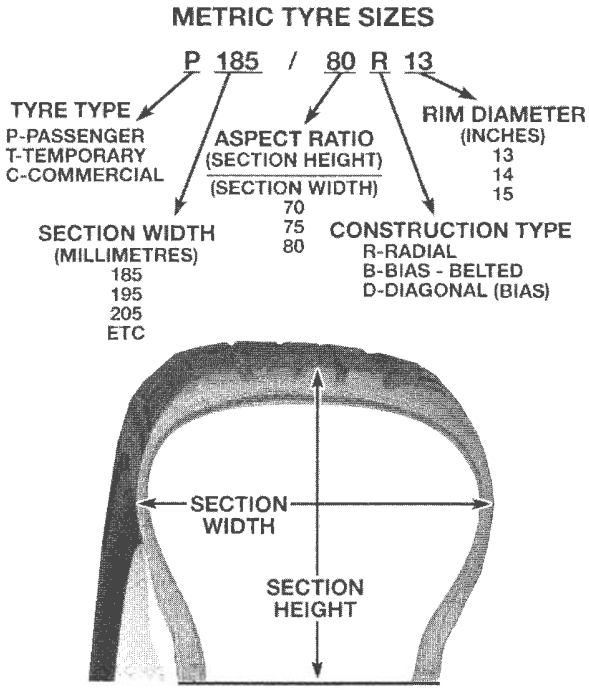
9 Remove the drivebelt (see Chapter 1).
10 Detach the inlet and outlet hoses from the power steering pump.
11 Remove the bolts and detach the pump.
12 Refitting is the reverse of removal. Renew the O-ring on the supply line fitting and lubricate it with power steering fluid before refitting. Tighten the pump bolts securely.

ALL MODELS

13 Bleed the power steering system (see Section 19).

19 Power steering system - bleeding

1 This is not a routine operation and normally will only be required when the system has been dismantled and reassembled.
2 Fill the reservoir to the correct level with fluid of the recommended type and allow it to remain undisturbed for at least two minutes.
3 Start the engine and run it for two or three seconds only. Check the reservoir and add more fluid as necessary.
4 Repeat the operations described in the preceding paragraph until the fluid level remains constant.
5 Raise the front of the vehicle until the wheels are clear of the ground.
6 Start the engine and increase the speed to about 1500 rpm. Now turn the steering wheel gently from stop-to-stop. Check the reservoir fluid level.
7 Lower the vehicle to the ground and, with the engine still running, move the vehicle forward sufficiently to obtain full right lock followed by full left lock. Recheck the fluid level. If the fluid in the reservoir is extremely foamy, allow the vehicle to stand for a few minutes with the engine switched off, then repeat the previous operations. At the same time, check the belt tightness and check for a bent or loose pulley. Check also to make sure the power steering hoses are not touching any other part of the vehicle, especially sheet metal or the exhaust manifold.
8 The procedures above will normally remedy an extreme foam condition and/or an objectionably noisy pump (low fluid level and/or air in the power steering fluid are the leading causes of this condition). If, however, either or both conditions persist after a few trials, the power steering system will have to be thoroughly checked. Do not drive the vehicle until the condition(s) have been remedied.



20.1 Metric tyre size code

20 Wheels and tyres - general information

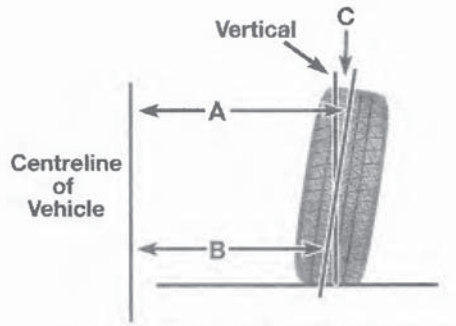
Refer to illustration 20.1

1 All vehicles covered by this manual are equipped with metric-sized fibreglass or steel-belted radial tyres (see illustration). Use of other size or type of tyres may affect the ride and handling of the vehicle. Don't mix different types of tyres, such as radials and bias belted, on the same vehicle as handling may be seriously affected. It's recommended that tyres be renewed in pairs on the same axle, but if only one tyre is being renewed, be sure it's the same size, structure and tread design as the other. Because tyre pressure has a substantial effect on handling and wear, the pressure on all tyres should be checked at least once a month or before any extended trips (see Chapter 1).
2 Wheels must be renewed if they are bent, dented, leak air, have elongated bolt holes, are heavily rusted, out of vertical symmetry or if the lug nuts won't stay tight. Wheel repairs that use welding or peening are not recommended.
3 Tyre and wheel balance is important to the overall handling, braking and performance of the vehicle. Unbalanced wheels can adversely affect handling and ride characteristics as well as tyre life. Whenever a tyre is refitted on a wheel, the tyre and wheel should be balanced by a shop with the proper equipment.

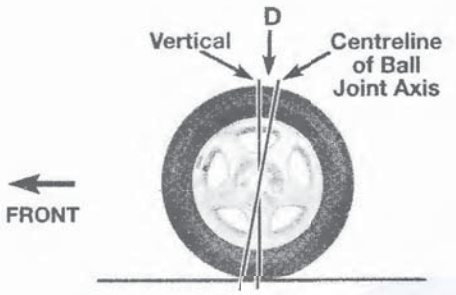
21 Front end alignment - general information

Refer to illustration 21.1

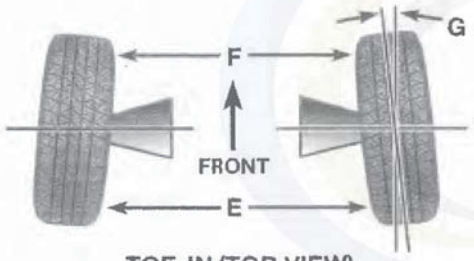
1 A front end alignment refers to the adjustments made to the front wheels so they are in proper angular relationship to the



CAMBER ANGLE (FRONT VIEW)



CASTER ANGLE (SIDE VIEW)



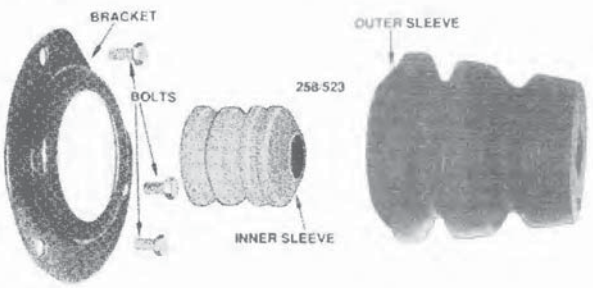
TOE-IN (TOP VIEW)

21.1 Front end alignment details

1 *A minus B = C (degrees camber)*
2 *D = caster (measured in degrees)*
3 *E minus F = toe-in (measured in inches)*
4 *G - toe-in (expressed in degrees)*

suspension and the ground (see illustration). Front wheels that are out of proper alignment not only affect steering control, but also increase tyre wear. Camber, caster and toe-in can be adjusted on the vehicles covered by this manual.

2 Getting the proper front wheel alignment is a very exacting process, one in which complicated and expensive machines are necessary to perform the job properly. Because of this, you should have a technician with the proper equipment perform these tasks. We will, however, use this space to give you a basic idea of what is involved with front end alignment so you can better understand the process and deal intelligently with the shop that does the work.



22.3 Typical exploded view of the assist spring components - (utility models only)

3 Camber is the tilting of the front wheels from vertical when viewed from the front of the vehicle. Caster is the tilting of the top of the front steering axis from the vertical, when viewed from the side of the vehicle. A tilt toward the rear is positive caster and a tilt toward the front is negative caster. Camber is controlled by the position of the steering knuckle in relation to the strut. Caster is adjusted by adding or subtracting shims between the front of the tension rod and the hydraulic damper.

4 Toe-in is the turning in of the front wheels. The purpose of a toe specification is to ensure parallel rolling of the front wheels. In a vehicle with zero toe-in, the distance between the front edges of the wheels will be the same as the distance between the rear edges of the wheels. The actual amount of toe-in is normally only a fraction of a mm. Toe-in adjustment is controlled by the position of the tie-rod end on the tie-rod. Incorrect toe-in will cause the tyres to wear improperly by making them scrub against the road surface.

22 Assist spring (utility models) - removal and refitting

Refer to illustration 22.3

1 Raise the rear of the vehicle and support it securely on jackstands.
2 Remove the rear wheels.
3 Remove the bolts retaining the assist spring mounting bracket to the vehicle underbody (see illustration) and remove the assist spring from the vehicle.
4 Separate the mounting bracket from the assist spring outer sleeve and remove the inner sleeve from the assist spring outer sleeve noting the installed direction.
5 Examine the assist spring components for damage, deterioration and wear. Renew components as necessary.
6 Do not apply any lubrication to the assist spring components.
7 Refit the inner sleeve to the direction noted on removal.
8 Refitting is the reverse of the removal procedure, tighten all the mounting bolts securely.

Notes

Chapter 11
Body

Contents

Specifications

Torque specifications	Nm
Front seat bolts	35 to 50
Seat belt anchor bolts	35 to 50

1 General information

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by a notice on the driver's door and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires.*

All models covered by this manual have a one-piece body and frame. Certain components are particularly vulnerable to accident damage and can be unbolted and repaired or renewed. Among these parts are the body mouldings, bumpers, doors, fenders, bonnet, luggage compartment lid and all the glass.

These models are of unitised construction. The frame consists of a floor pan with front and rear frame side rails which support the body components, front and rear suspension systems and other mechanical components.

Some body panels are made of special plastic compounds. These are resistant to minor damage but they cannot be repaired using conventional body repair or painting techniques.

Only general body maintenance practices and body panel repair procedures within the scope of the average home mechanic are included in this Chapter.

2 Body - maintenance

1 The condition of your vehicle's body is very important, because the resale value depends a great deal on it. It's much more difficult to repair a neglected or damaged body than it is to repair mechanical components. The hidden areas of the body, such as the wheel wells, the frame and the engine compartment, are equally important, although they don't require as frequent attention as the rest of the body.

2 Once a year, or every 20,000 kilometres, it's a good idea to have the underside of the body steam cleaned. All traces of dirt and oil will be removed and the area can then be inspected carefully for rust, damaged brake lines, frayed electrical wires, damaged cables and other problems. The front suspension components should be greased after completion of this job.

3 At the same time, clean the engine and the engine compartment with a steam cleaner or water soluble degreaser.

4 The wheel wells should be given close attention, since undercoating can peel away and stones and dirt thrown up by the tyres can cause the paint to chip and flake, allowing rust to set in. If rust is found, clean down to the bare metal and apply an anti-rust paint.

5 The body should be washed about once a week. Wet the vehicle thoroughly to soften the dirt, then wash it down with a soft sponge and plenty of clean soapy water. If the surplus dirt is not washed off very carefully, it can wear down the paint.

6 Spots of tar thrown up from the road should be removed with a cloth soaked in solvent.

7 Once every six months, wax the body and chrome trim. If a chrome cleaner is used to remove rust from any of the vehicle's plated parts, remember that the cleaner also removes part of the chrome, so use it sparingly.

3 Vinyl trim - maintenance

Don't clean vinyl trim with detergents, caustic soap or petroleum-based cleaners. Plain soap and water works just fine, with a soft brush to clean dirt that may be ingrained. Wash the vinyl as frequently as the rest of the vehicle.

After cleaning, application of a high quality rubber and vinyl protectant will help prevent oxidation and cracks. The protectant can also be applied to weatherstripping, vacuum lines, rubber hoses, and to tyres.

4 Upholstery and carpets - maintenance

1 Every three months, remove the carpets or mats and clean the interior of the vehicle (more frequently if necessary). Vacuum the upholstery and carpets to remove loose dirt and dust.

2 Leather upholstery requires special care. Stains should be removed with warm water and a very mild soap solution. Use a clean, damp cloth to remove the soap, then wipe again with a dry cloth. Never use alcohol, petrol, nail polish remover or thinner to clean leather upholstery.

3 After cleaning, regularly treat leather upholstery with a leather wax. Never use car wax on leather upholstery.

4 In areas where the interior of the vehicle is subject to bright sunlight, cover leather seats with a sheet if the vehicle is to be left out for any length of time.

5 Use of an interior-type windscreen sun deflector is also recommended.

5 Body repair - minor damage

See photo sequence

REPAIR OF MINOR SCRATCHES

1 If the scratch is superficial and does not penetrate to the metal of the body, repair is very simple. Lightly rub the scratched area with a fine rubbing compound to remove loose paint and built up wax. Rinse the area with clean water.

2 Apply touch-up paint to the scratch, using a small brush. Continue to apply thin layers of paint until the surface of the paint in the scratch is level with the surrounding paint. Allow the new paint at least two weeks to harden, then blend it into the surrounding paint by rubbing with a very fine rubbing compound. Finally, apply a coat of wax to the scratch area.

3 If the scratch has penetrated the paint and exposed the metal of the body, causing the metal to rust, a different repair technique is required. Remove all loose rust from the bottom of the scratch with a pocket knife, then apply rust-inhibiting paint to prevent the formation of rust in the future. Using a rubber or nylon applicator, coat the scratched area with glaze-type filler. If required, the filler can be mixed with thinner to provide a very thin paste, which is ideal for filling narrow scratches. Before the glaze filler in the scratch hardens, wrap a piece of smooth cotton cloth around the tip of a finger. Dip the cloth in thinner and then quickly wipe it along the surface of the scratch. This will ensure that the surface of the filler is slightly hollow. The scratch can now be painted over as described earlier in this Section.

REPAIR OF DENTS

4 When repairing dents, the first job is to pull the dent out until the affected area is as close as possible to its original shape. There is no point in trying to restore the original shape completely as the metal in the damaged area will have stretched on impact and cannot be restored to its original contours. It is better to bring the level of the dent up to a point which is about 3 mm below the level of the surrounding metal. In cases where the dent is very shallow, it is not worth trying to pull it out at all.

5 If the back side of the dent is accessible, it can be hammered out gently from behind using a soft-face hammer. While doing this, hold a block of wood firmly against the opposite side of the metal to absorb the hammer blows and prevent the metal from being stretched.

6 If the dent is in a section of the body which has double layers, or some other factor makes it inaccessible from behind, a different technique is required. Drill several small holes through the metal inside the damaged area, particularly in the deeper sections. Screw long, self-tapping screws into the holes just enough for them to get a good grip in the metal. Now the dent can be pulled out by pulling on the protruding heads of the screws with locking pliers.

7 The next stage of repair is the removal of paint from the damaged area and from 2 cm or so of the surrounding metal.

This is easily done with a wire brush or sanding disk in a drill motor, although it can be done just as effectively by hand with sandpaper. To complete the preparation for filling, score the surface of the bare metal with a screwdriver or the tang of a file, or drill small holes in the affected area. This will provide a good grip for the filler material. To complete the repair, see the Section on filling and painting.

REPAIR OF RUST HOLES OR GASHES

8 Remove all paint from the affected area and from 2 cm or so of the surrounding metal using a sanding disk or wire brush mounted in a drill motor. If these are not available, a few sheets of sandpaper will do the job just as effectively.

9 With the paint removed, you will be able to determine the severity of the corrosion and decide whether to renew the whole panel, if possible, or repair the affected area. New body panels are not as expensive as most people think, and it is often quicker to fit a new panel than to repair large areas of rust.

10 Remove all trim pieces from the affected area except those which will act as a guide to the original shape of the damaged body, such as headlight shells, etc. Using metal snips or a hacksaw blade, remove all loose metal and any other metal that is badly affected by rust. Hammer the edges of the hole inward to create a slight depression for the filler material.

11 Wire brush the affected area to remove the powdery rust from the surface of the metal. If the back of the rusted area is accessible, treat it with rust-inhibiting paint.

12 Before filling is done, block the hole in some way. This can be done with sheet metal riveted or screwed into place, or by stuffing the hole with wire mesh.

13 Once the hole is blocked off, the affected area can be filled and painted. See the following subsection on filling and painting.

FILLING AND PAINTING

14 Many types of body fillers are available, but generally speaking, body repair kits which contain filler paste and a tube of resin hardener are best for this type of repair work. A wide, flexible plastic or nylon applicator will be necessary for imparting a smooth and contoured finish to the surface of the filler material. Mix up a small amount of filler on a clean piece of wood or cardboard (use the hardener sparingly). Follow the manufacturer's instructions on the package, otherwise the filler will set incorrectly.

15 Using the applicator, apply the filler paste to the prepared area. Draw the applicator across the surface of the filler to achieve the desired contour and to level the filler surface. As soon as a contour that approximates the original one is achieved, stop working the paste. If you continue, the paste will begin to stick to the applicator. Continue to add thin layers of paste at 20-minute intervals until the level of the filler is just above the surrounding metal.

16 Once the filler has hardened, the excess can be removed with a body file. From then on, progressively finer grades of sandpaper should be used, starting with a 180-grit paper and finishing with 400-grit wet-or-dry paper. Always wrap the sandpaper around a flat rubber or wooden block, otherwise the surface of the filler will not be completely flat. During the sanding of the filler surface, the wet-or-dry paper should be periodically rinsed in water. This will ensure that a very smooth finish is produced in the final stage.

17 At this point, the repair area should be surrounded by a ring of bare metal, which in turn should be encircled by the finely feathered edge of good paint. Rinse the repair area with clean water until all of the dust produced by the sanding operation is gone.

18 Spray the entire area with a light coat of primer. This will reveal any imperfections in the surface of the filler. Repair the imperfections with fresh filler paste or glaze filler and once more smooth the surface with sandpaper. Repeat this spray-and-repair procedure until you are satisfied that the surface of the filler and the feathered edge of the paint are perfect. Rinse the area with clean water and allow it to dry completely.

19 The repair area is now ready for painting. Spray painting must be carried out in a warm, dry, windless and dust-free atmosphere. These conditions can be created if you have access to a large indoor work area, but if you are forced to work in the open, you will have to pick the day very carefully. If you are working indoors, dousing the floor in the work area with water will help settle the dust which would otherwise be in the air. If the repair area is confined to one body panel, mask off the surrounding panels. This will help minimise the effects of a slight mismatch in paint colour. Trim pieces such as chrome strips, door handles, etc., will also need to be masked off or removed. Use masking tape and several thickness of newspaper for the masking operations.

20 Before spraying, shake the paint can thoroughly, then spray a test area until the spray painting technique is mastered. Cover the repair area with a thick coat of primer. The thickness should be built up using several thin layers of primer rather than one thick one. Using 600-grit wet-or-dry sandpaper, rub down the surface of the primer until it is very smooth. While doing this, the work area should be thoroughly rinsed with water and the wet-or-dry sandpaper periodically rinsed as well. Allow the primer to dry before spraying additional coats.

21 Spray on the top coat, again building up the thickness by using several thin layers of paint. Begin spraying in the centre of the repair area and then, using a circular motion, work out until the whole repair area and about 5 cm of the surrounding original paint is covered. Remove all masking material 10 to 15 minutes after spraying on the final coat of paint. Allow the new paint at least two weeks to harden, then use a very fine rubbing compound to blend the edges of the new paint into the existing paint. Finally, apply a coat of wax.

6 Body repair - major damage

1 Major damage must be repaired by a properly equipped auto body shop. These shops have the specialised equipment required to do the job properly.

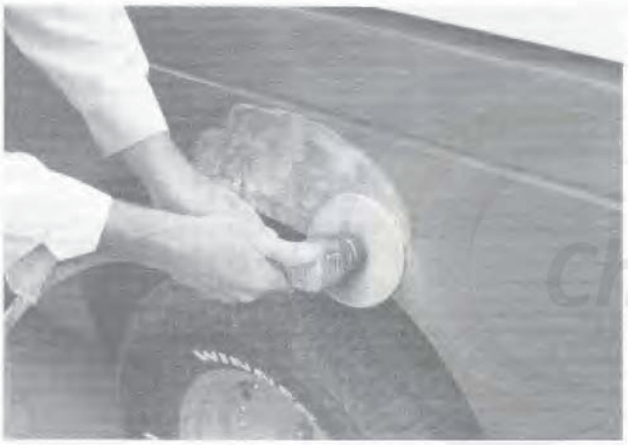
2 If the damage is extensive, the body must be checked for proper alignment or the vehicle's handling characteristics may be adversely affected and other components may wear at an accelerated rate.

3 Due to the fact that all of the major body components (bonnet, fenders, etc.) are separate and replaceable units, any seriously damaged components should be renewed rather than repaired. Sometimes the components can be found in a wrecking yard that specialises in used vehicle components, often at considerable savings over the cost of new parts.

These photos illustrate a method of repairing simple dents. They are intended to supplement Body repair - minor damage in this Chapter and should not be used as the sole instructions for body repair on these vehicles.

1 If you can't access the backside of the body panel to hammer out the dent, pull it out with a slide-hammer-type dent puller. In the deepest portion of the dent or along the crease line, drill or punch hole(s) at least one inch apart . . .

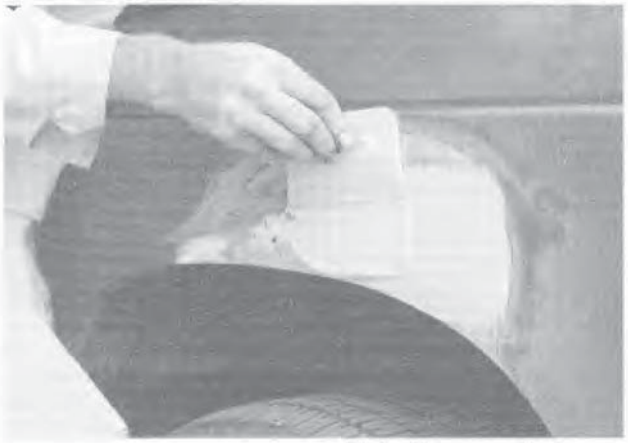
2 . . . then screw the slide-hammer into the hole and operate it. Tap with a hammer near the edge of the dent to help 'pop' the metal back to its original shape. When you're finished, the dent area should be close to its original contour and about 3 mm below the surface of the surrounding metal



3 Using coarse-grit sandpaper, remove the paint down to the bare metal. Hand sanding works fine, but the disc sander shown here makes the job faster. Use finer (about 320-grit) sandpaper to feather-edge the paint at least one inch around the dent area

4 When the paint is removed, touch will probably be more helpful than sight for telling if the metal is straight. Hammer down the high spots or raise the low spots as necessary. Clean the repair area with wax/silicone remover

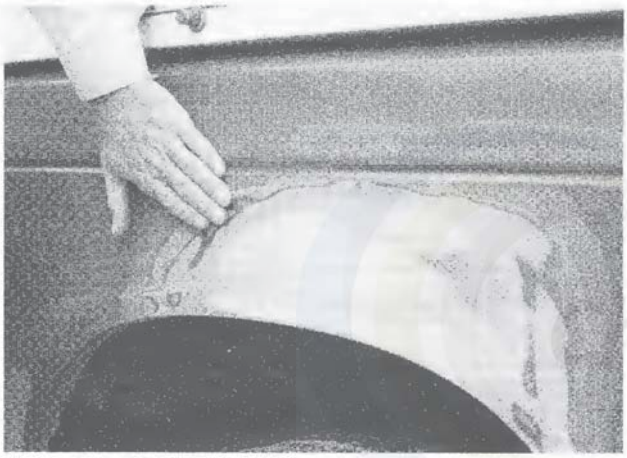
5 Following label instructions, mix up a batch of plastic filler and hardener. The ratio of filler to hardener is critical, and, if you mix it incorrectly, it will either not cure properly or cure too quickly (you won't have time to file and sand it into shape)



6 Working quickly so the filler doesn't harden, use a plastic applicator to press the body filler firmly into the metal, assuring it bonds completely. Work the filler until it matches the original contour and is slightly above the surrounding metal

7 Let the filler harden until you can just dent it with your fingernail. Use a body file or Surform tool (shown here) to rough-shape the filler

8 Use coarse-grit sandpaper and a sanding board or block to work the filler down until it's smooth and even. Work down to finer grits of sandpaper - always using a board or block - ending up with 360 or 400 grit



9 You shouldn't be able to feel any ridge at the transition from the filler to the bare metal or from the bare metal to the old paint. As soon as the repair is flat and uniform, remove the dust and mask off the adjacent panels or trim pieces

10 Apply several layers of primer to the area. Don't spray the primer on too heavy, so it sags or runs, and make sure each coat is dry before you spray on the next one. A professional-type spray gun is being used here, but aerosol spray primer is available inexpensively from auto parts stores

11 The primer will help reveal imperfections or scratches. Fill these with glazing compound. Follow the label instructions and sand it with 360 or 400-grit sandpaper until it's smooth. Repeat the glazing, sanding and respraying until the primer reveals a perfectly smooth surface

12 Finish sand the primer with very fine sandpaper (400 or 600-grit) to remove the primer overspray. Clean the area with water and allow it to dry. Use a tack rag to remove any dust, then apply the finish coat. Don't attempt to rub out or wax the repair area until the paint has dried completely (at least two weeks)

9.1 Pad the back corners of the bonnet with rags so the paint or the windscreen won't be damaged if the bonnet accidentally swings rearward

9.4 Remove the bolt (arrow) on each side of the bonnet

7 Hinges and locks - maintenance

Once every 5,000 kilometres, or every three months, the hinges and latch assemblies on the doors, bonnet and luggage compartment should be given a few drops of light oil or lock lubricant. The door latch strikers should also be lubricated with a thin coat of grease to reduce wear and ensure free movement. Lubricate the door and luggage compartment locks with spray-on graphite lubricant.

8 Windscreen and fixed glass - renewal

Renewal of the windscreen and fixed glass requires the use of special fast-setting adhesive/caulk materials and some specialised tools and techniques. These operations should be left to a dealer service department or a shop specialising in glass work.

9 Bonnet - removal, refitting and adjustment

Note: *The bonnet is heavy and somewhat awkward to remove and refit - at least two people should perform this procedure.*

REMOVAL AND REFITTING

Refer to illustrations 9.1 and 9.4

1 Use blankets or pads to cover the fenders and rear of the bonnet (see illustration). This will protect the windscreen, body and paint as the bonnet is lifted off.

2 Disconnect any wires or hoses which will interfere with removal. Scribe a line around the entire hinge plate and bolts to reposition the bonnet at refitting.

3 Detach the support struts (see Section 11).

4 With an assistant supporting the weight of the bonnet, remove the retaining bolts and lift off the bonnet (see illustration).

5 Refitting is the reverse of the removal procedure.

ADJUSTMENT

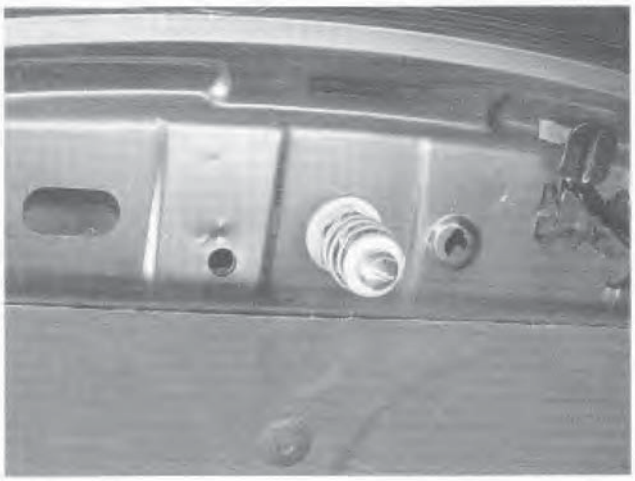
Refer to illustrations 9.9 and 9.11

6 Fore-and-aft and side-to-side adjustment of the bonnet is done by moving the bonnet in relation to the hinge plate after loosening the bolts or nuts.

7 Scribe a line around the entire hinge plate so you can judge the amount of movement if you haven't already done so.

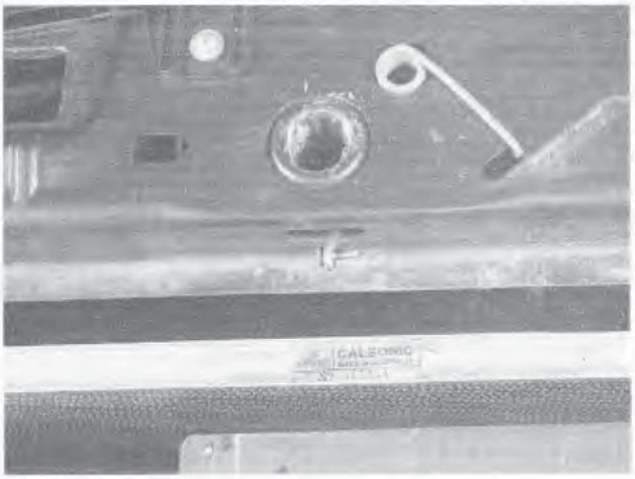
8 Loosen the bolts or nuts and move the bonnet into correct alignment. Move it only a little at a time. Tighten the hinge bolts or nuts and carefully lower the bonnet to check the alignment.

9 If necessary after refitting, the entire bonnet striker assembly can be adjusted up and down so the bonnet closes securely and is flush with the fenders. To do this, screw the striker in or out as necessary (see illustration).



9.9 Turn the bonnet striker in or out with a flat blade screwdriver until the bonnet meets the fenders properly

9.11 The bumpers on the underside of the bonnet can be adjusted by screwing them in or out



10.2 Detach the bonnet release cable by rotating it out of the latch arm

10 The rear of the bonnet can be adjusted by loosening and repositioning the hinges.

11 Finally, adjust the bonnet bumpers so the bonnet, when closed, is flush with the fenders (see illustration).

12 The bonnet latch assembly, as well as the hinges, should be periodically lubricated with white lithium-base grease to prevent sticking and wear.

10 Bonnet latch release cable - renewal

Refer to illustration 10.2

1 Remove the radiator shroud for access.

2 Detach the cable from the hook in the end of the latch arm (see illustration).

3 Release the cable from the retaining clip in the engine compartment.

4 From inside the car, detach the release handle, then pull the entire assembly out and towards the rear.

5 Refitting is the reverse of removal.

11 Support struts - removal and refitting

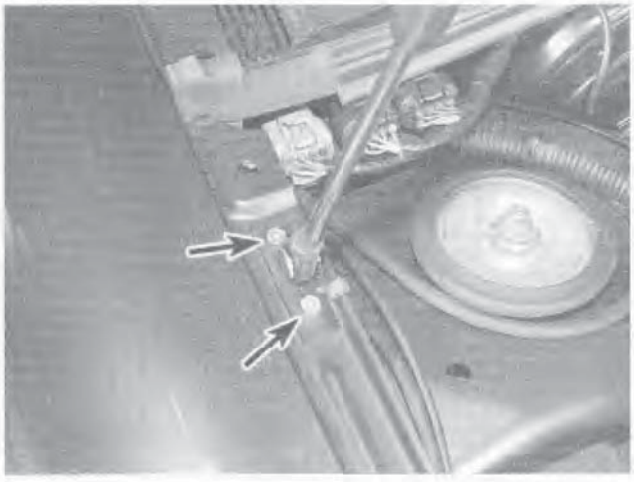
Refer to illustrations 11.2a and 11.2b

1 Support the bonnet, lid or tailgate in the fully open position.

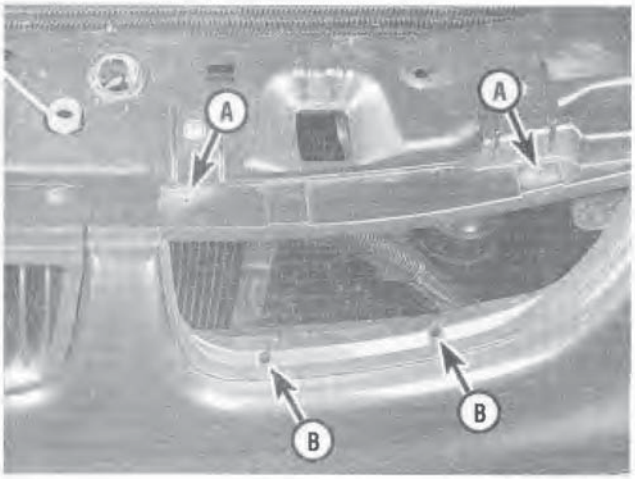
2 Detach the clip at the end of the strut with a flat-bladed screwdriver (see illustrations). The strut can then be pulled off the pivot.

3 Refitting is the reverse of removal, taking care to renew the supports with ones of the correct length and capacity.

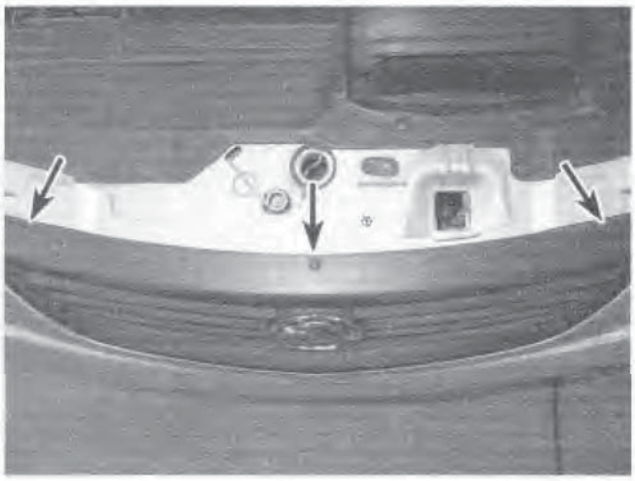
11.2a Use a screwdriver to detach the clip (arrow) at the end of the strut



11.2b Remove the bolts (arrows) and detach the lower end of strut



12.2a On VXII and earlier models, remove the screws (A) and lift the radiator grille out of the tabs (B)

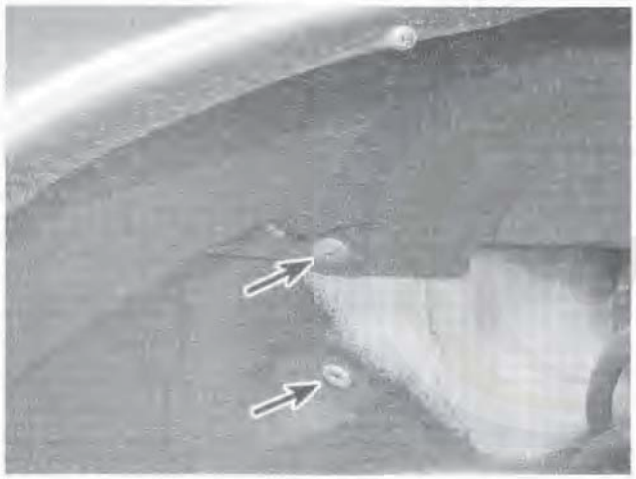


12.2b On VY and later models, remove the three mounting screws and lift the grill

12 Radiator grille - removal and refitting

Refer to illustrations 12.2a and 12.2b

1 Raise the bonnet.
2 Remove the screws and pull the grille straight up to detach the tabs from the rubber grommets at the bottom, then lift the grille out (see illustrations).
3 Refitting is the reverse of removal.



13.2 Remove the plastic screw fasteners (arrows) and detach the fender liner

13 Front fender - removal and refitting

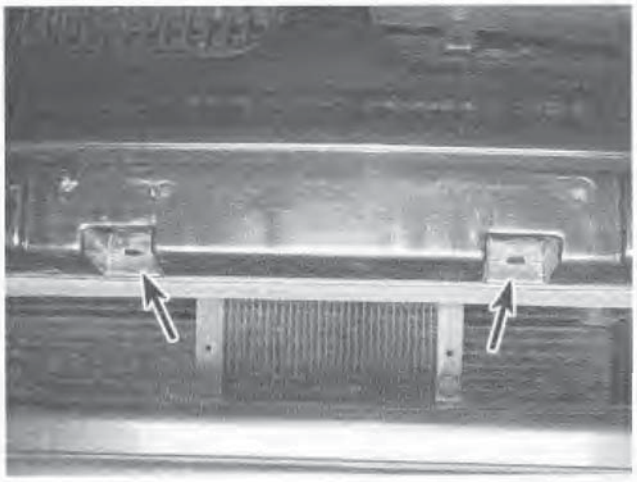
Refer to illustrations 13.2, 13.3a, 13.3b and 13.3c

1 Remove the front bumper. See Section 14.
2 Remove the liner from inside the fender (see illustration).
3 The fender is secured with several fasteners (see illustrations). Remove all the bolts while an assistant helps with the last few.
4 The refitting is the reverse of removal.

13.3a After detaching the cover, remove the two bolts at the rear lower edge of the fender (arrows), then ...

13.3b ... remove the bolts below the headlight (arrows), followed by ...

13.3c ... the bolts (arrows) along the upper edge of the fender



14.3 After removing the number plate, remove the two plastic rivets (arrows) retaining the front lower edge of the bumper cover

14.4 Remove these screws retaining the front bumper cover to the radiator support

14 Bumpers - removal and refitting

Note: *Consult an automotive paint professional before attempting to paint a plastic bumper. Conventional finishes will not perform properly and may damage the bumper.*

FRONT BUMPER

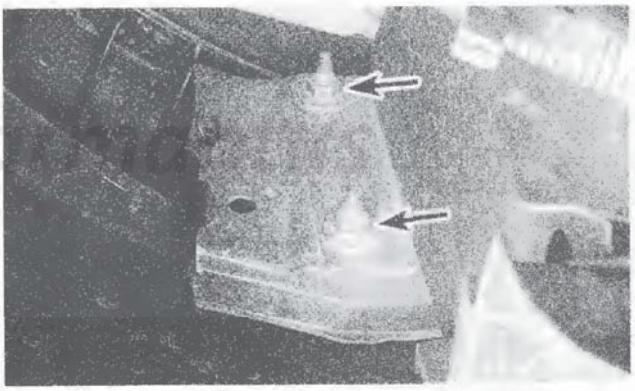
Refer to illustrations 14.3, 14.4 and 14.6

1 Raise the vehicle and support it securely on jackstands.
2 Disconnect any electrical wiring that will interfere with removal.
3 Remove the plastic rivets behind the number plate opening (see illustration).
4 Remove the screws retaining the bumper to the radiator brace (see illustration).
5 Support the bumper and remove the bolts retaining the ends of the bumper to the fender wheel arches.
6 Remove the retaining nuts and remove the bumper (see illustration).
7 Refitting is the reverse of removal.

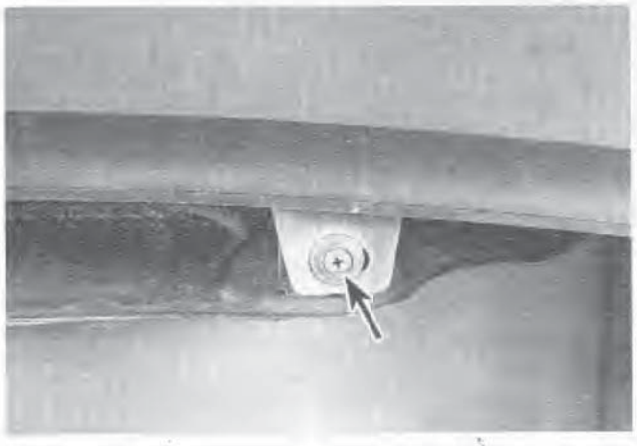
REAR BUMPER

Refer to illustrations 14.8a, 14.8b, 14.9 and 14.10

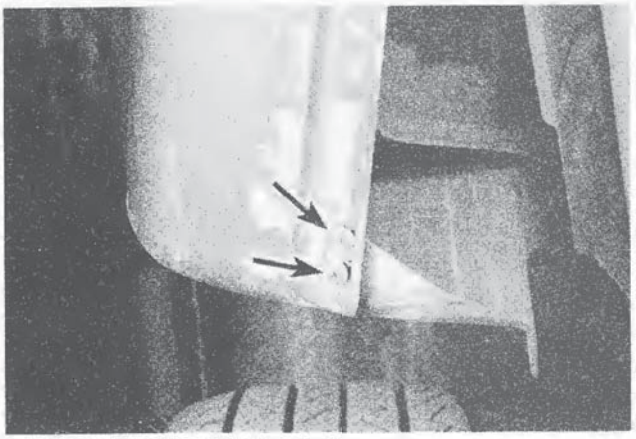
8 Remove the two screws at each wheel arch opening and the two screws at the lower edge of the bumper (see illustrations).



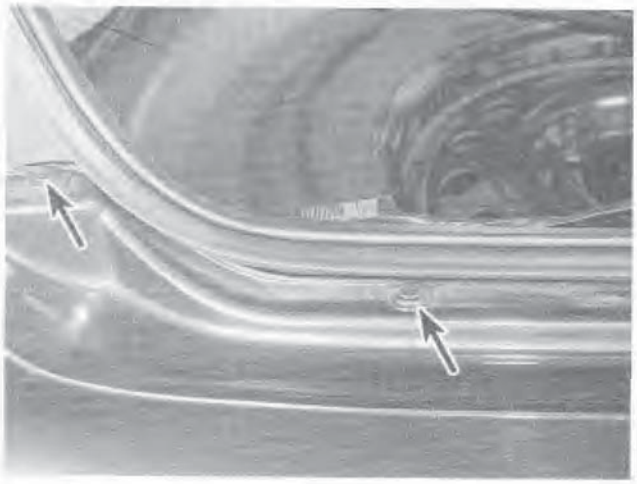
14.6 Remove the front bumper retaining nuts (arrows)



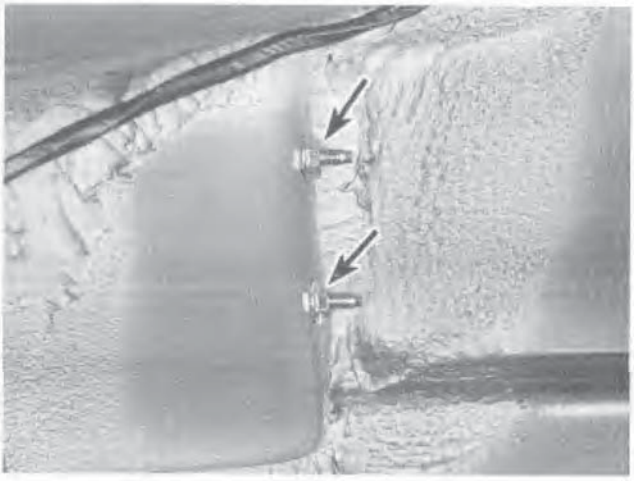
14.8a Remove the two plastic rivets (arrow) on the bottom of the rear bumper



14.8b Remove the four plastic screws (arrows, two shown) behind each wheel arch



14.9 Remove the six plastic screws (arrows, two shown) along the top of the rear bumper



14.10 Open the luggage compartment for access to the four rear bumper nuts (arrows, two shown)

9 Remove the two plastic screws at the bottom edge and the six screws along the top of the bumper (see illustration).

10 Working inside the rear compartment, remove the four nuts retaining the bumper to the body (see illustration).

11 Have an assistant help support the bumper and remove it from the vehicle.

12 Refitting is the reverse of removal.

15 Door trim panel - removal and refitting

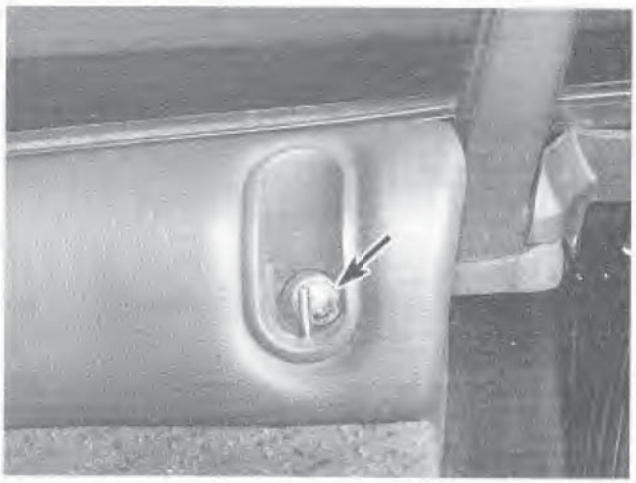
Refer to illustrations 15.2, 15.3a, 15.3b, 15.7, 15.8 and 15.9

1 Disconnect the earth (-) lead from the battery.

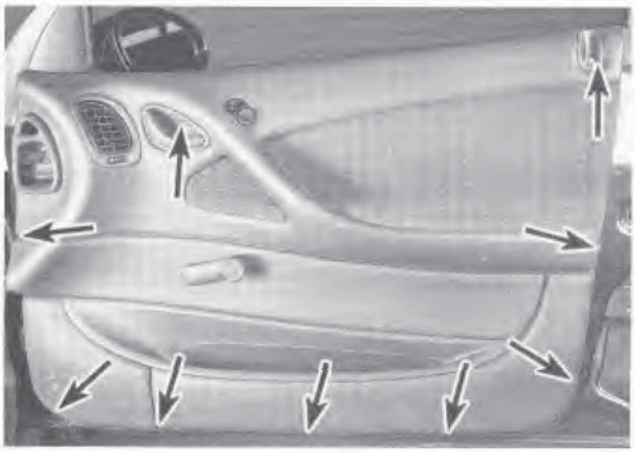
Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

15.2 A special tool for detaching the retaining clip makes removing the window crank easier

15.3a The door lock button is held in place by a plastic clip and a screw - since the clip will probably be destroyed on removal, obtain several from your dealer before beginning work



15.3b Remove the screw revealed by the removal of the plastic clip



15.7 Door trim panel screw locations (arrows)

15.8 Press in on the centre of the door trim panel to release the internal clip, then lift it straight up and remove it

2 If equipped with manual windows, use a special handle removing tool to remove the window regulator handles (see illustration).

3 Prise out the retaining clip, remove the screw and lift off the door lock button (see illustrations).

> ***Note:*** *Removing the door lock button retaining clip will destroy it. It is a good idea to obtain renewal retainers from a dealer before beginning work.*

4 Remove the inner door handle (see Section 17), then remove the retaining screw inside the handle opening.

5 Using a small screwdriver, prise out the power mirror switch.

6 Prise off the front door outside mirror cover.

7 Remove the door trim panel screws (see illustration).

8 Press in on the centre to detach the clip, then lift the panel up and off the door channel (see illustration). Disconnect any wiring connectors and remove the panel.

9 For access to the inner door, carefully peel back the plastic water shield, taking care not to tear it (see illustration).

10 Refitting is the reverse of removal. Be sure to renew the plastic water shield if necessary.

16 Door - removal and refitting

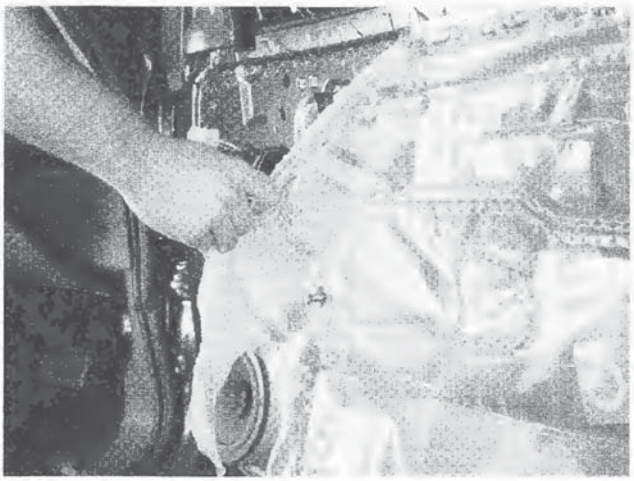
Refer to illustrations 16.3, 16.4a and 16.4b

1 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

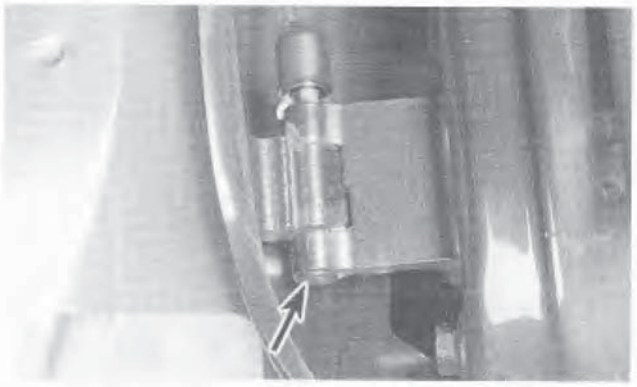
2 Unplug the electrical harness from the door pillar connector.

3 Disconnect the door stop assembly. Remove the door stop retaining pin or bolt (see illustration).



15.9 For access to the inner door components, peel back the plastic water shield - if you're careful, it can be reused

16.3 The door stop assembly can be disconnected by removing the pin or bolt (arrow)



16.4a Prise out the lower door hinge cover (arrow)

16.4b Remove the upper cover (arrow) and drive the hinge retaining sleeve upward to remove it

4 Remove the covers from the hinge pins (see illustrations).

5 Position a floor jack under the door or have an assistant on hand to support the door when the hinge pins are removed.

> ***Note:*** *If a jack is used, place a rag between it and the door to protect the door's paint.*

6 Drive out the hinge sleeves from the bottom using special tool AU170 or its equivalent, such as a long punch. Do the lower one first.

7 Refitting is the reverse of removal, taking care to refit the covers on the hinge pins. Reconnect the door stop links.

17 Door lock cylinder, latch and handles - removal and refitting

1 Disconnect the earth (-) lead from the battery.

> **Caution:** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Raise the window, remove the trim panel (see Section 15) and peel back the water deflector sufficiently to gain access to the components. Remove the screws and detach the door trim panel bracket.

LOCK CYLINDER AND FRONT EXTERIOR HANDLE

Refer to illustration 17.4

3 Working from inside the door, disconnect the rod from the lock.

4 Remove the retaining nuts and withdraw the exterior handle and lock cylinder assembly, unplug any electrical connectors and remove the assembly from the door (see illustration).

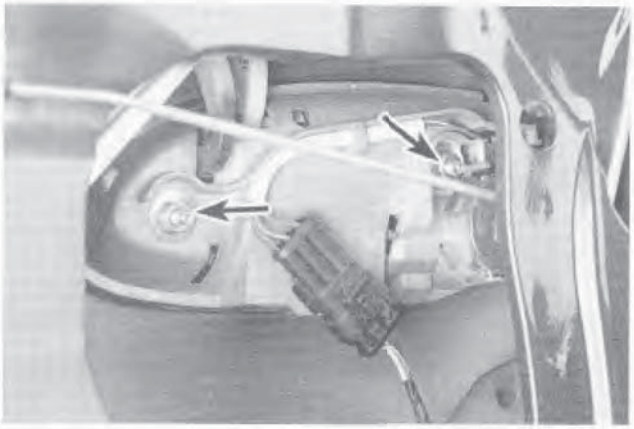
5 Refitting is the reverse of removal. If for some reason the "free-turning" lock cylinder goes into the free-turning mode, it can be reset. Insert the proper key fully into the lock in the vertical position and slowly turn it anti-clockwise until you feel a click. Turn the key slowly clockwise until it clicks again and make sure it is again in the vertical position, then remove it. If the procedure doesn't work, turn the key anti-clockwise 180-degrees and repeat it.

LATCH

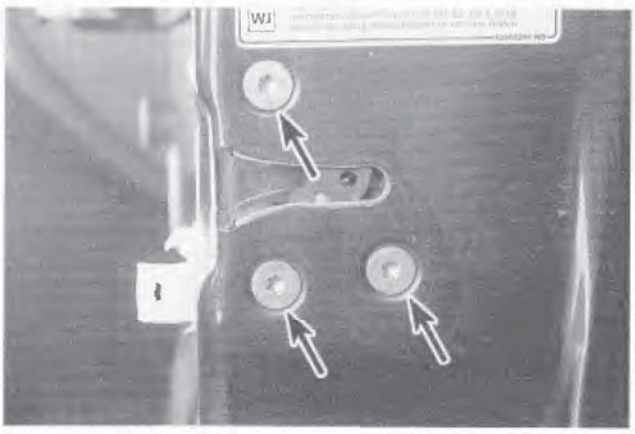
Refer to illustration 17.7

6 Remove the door panel (see Section 15).

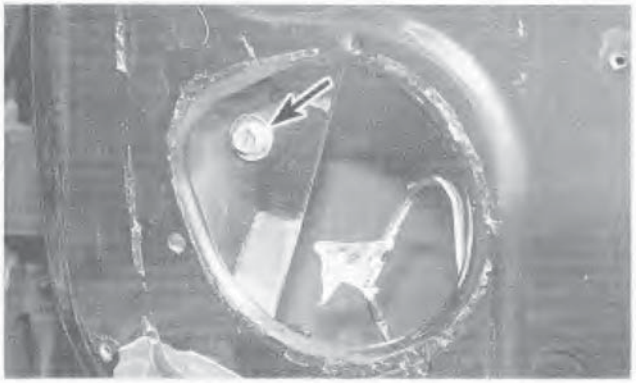
7 Remove the retaining screws in the end of the door, lower the latch assembly, disengage the lock rod and lower the assembly from the door (see illustration).



17.4 After disconnecting the lock cylinder rod, remove the two nuts (arrows), unplug the connector and detach the door handle assembly



17.7 Remove these screws (arrows) to renew the latch



18.2 Remove the bolts retaining the front window guide channel and remove the channel (lower bolt shown)

8 Refitting is the reverse of removal. Tighten the retaining screws securely.

INNER HANDLE

9 Prise off the cover, remove the screw and disconnect the rod from the handle.

10 Refitting is the reverse of removal. Make sure that the rod is engaged securely.

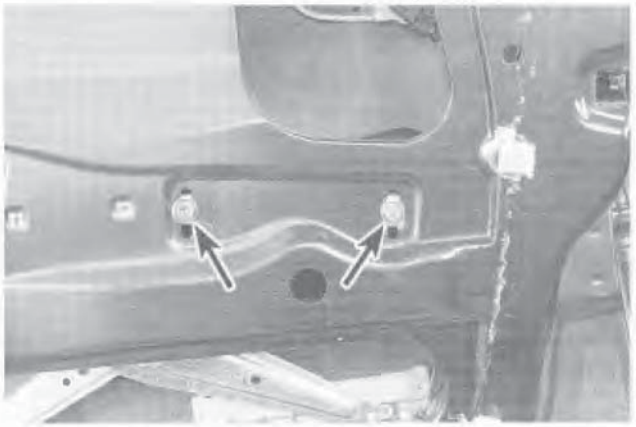
18 Door window glass - removal and refitting

Refer to illustrations 18.2 and 18.3

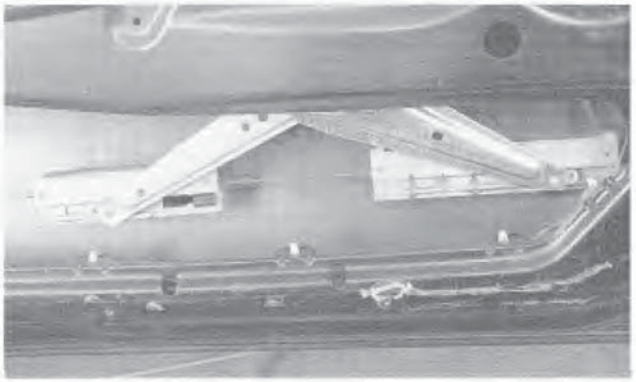
1 Remove the door trim panel and water shield (see Section 15). Remove the outside rear view mirror (see Section 27).

2 Carefully prise off the interior and exterior sealing strip/mouldings at the top of the door. Remove the bolts retaining the front guide channel and remove the channel (see illustration).

3 Temporarily refit the window crank handle or connect the power window switch. Position the window with the roller guides near the end of the glass channel (see illustration). Grasp the top of the glass and move the glass forward until the roller guides slide out of the glass channel.



19.3a Remove the bolts retaining the lifter arm guide channel to the door frame. Note they are in slots for window glass adjustments



18.3 Move the glass forward until the roller guide slides out of the glass channel

4 Lift the window out of the door frame, tilting the rear of the glass up.

5 Refitting is the reverse of removal.

19 Window regulator - removal and refitting

REMOVAL

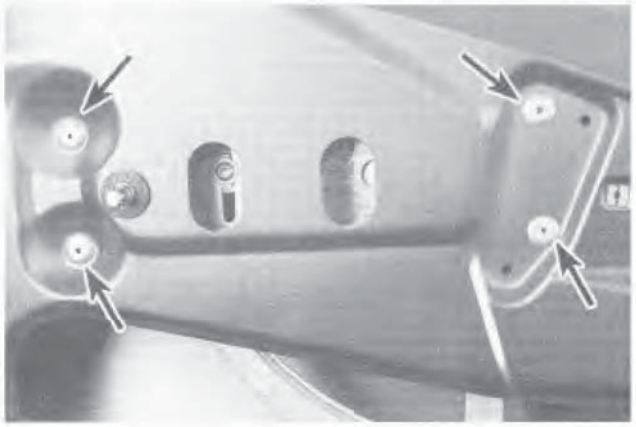
Refer to illustrations 19.3a and 19.3b

1 Disconnect the earth (-) lead from the battery.

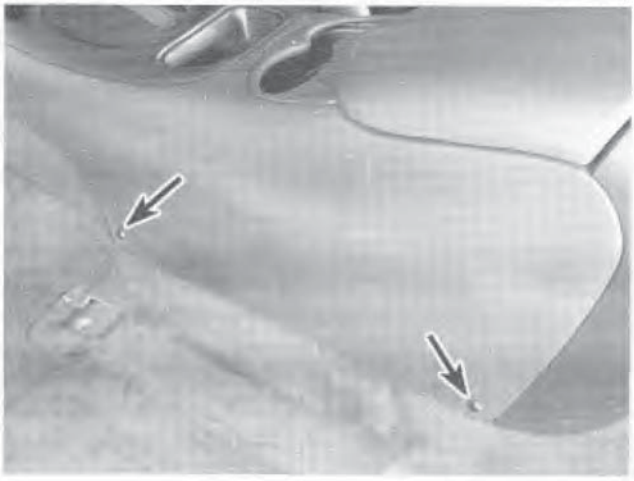
> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the trim panel and water shield (see Section 15). Disconnect the electrical connector from the window motor (if equipped) and remove the door window glass (see Section 18).

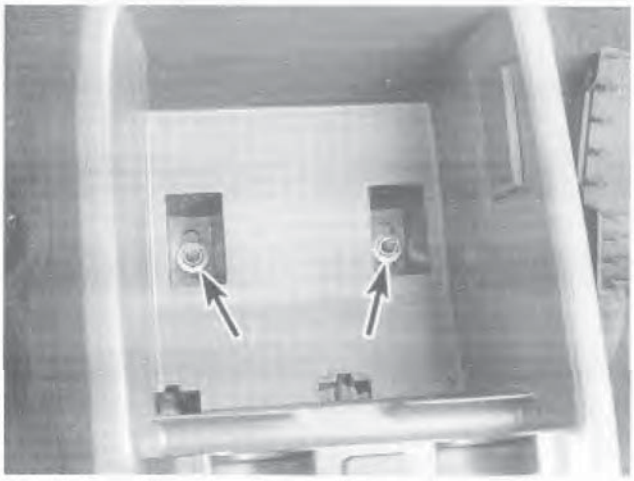
3 Remove the bolts retaining the lifter arm channel and drill out the rivets retaining the window regulator to the door frame (see illustrations).



19.3b Using the appropriate size drill bit, drill the centre out of the window regulator rivets (arrows) and remove the rivets

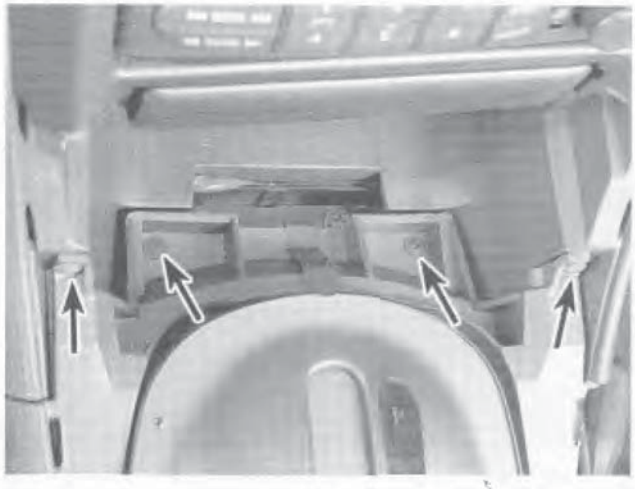


20.2 Remove the screws (arrows) along the base on both sides of the console



20.3 Open the console lid, remove the insert and remove the retaining nuts (arrows)

20.4a Remove the screws (arrows) and detach the ashtray cover...



20.4b ...then remove the four screws (arrows) retaining the console to the instrument panel cover

4 Remove the regulator through the opening in the door frame.

REFITTING

5 Check that the rollers turn freely. Lubricate them with white grease.

6 Position the regulator in the door and attach the regulator with the bolts included in the renewal kit.

7 The rest of the refitting is the reverse of removal.

20 Console - removal and refitting

Refer to illustrations 20.2, 20.3, 20.4a and 20.4b

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by a notice on the driver's door and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, centre console, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

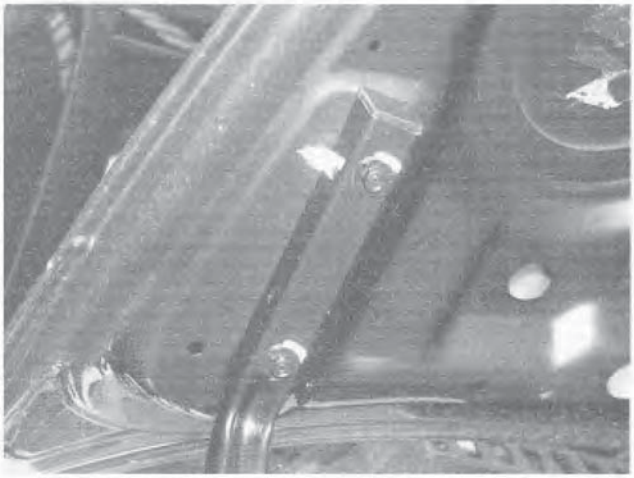
2 Remove the console-to-transmission tunnel screws (see illustration). It will be necessary to move the seats forward for access to the rear screws.

3 Open the console door, lift out the rubber insert and remove the two retaining nuts (see illustration).

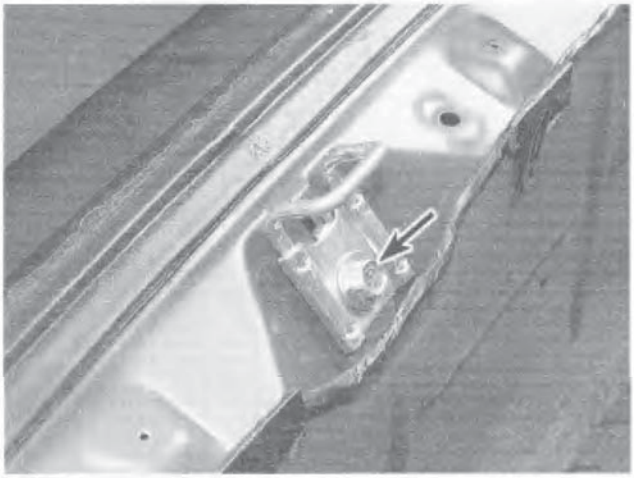
4 Prise out the rubber cover at the front of the console and remove the screws attaching the front of the console to the centre fascia (see illustrations).

5 Detach the console, unplug the electrical harness, then remove the console from the vehicle. Do not disturb any of the airbag components or wiring.

6 Refitting is the reverse of removal.



21.3 Use a marking pen to mark the hinge arm location before removing the bolts



21.8 The height of the lid can be adjusted by loosening the lock striker bolt and raising or lowering the striker

21 Luggage compartment lid - removal, refitting and adjustment

Refer to illustrations 21.3 and 21.8

1 Open the luggage compartment lid and cover the edges of the luggage compartment with pads or cloths to protect the painted surfaces when the lid is removed.

2 Disconnect any cables or electrical connectors attached to the luggage compartment lid that would interfere with removal.

3 Detach the corner of the lid trim cover for access and use a marking pen to make alignment marks around the hinges (see illustration).

4 While an assistant supports its weight, remove the hinge bolts on both sides and lift the luggage compartment lid off.

5 Refitting is the reverse of the removal procedure. When reinstalling the lid, align the hinges with the marks made during removal.

6 After refitting, close the lid and make sure it's in proper alignment with the surrounding body panels. Fore-and-aft adjustments of the lid are controlled by the position of the bolts in the hinge arms. To adjust it, loosen the hinge bolts, reposition the lid and retighten the bolts.

7 Up-and-down movement of the lid is adjusted by loosening the hinge bolts and inserting or removing shims between the lid and the hinge, then tightening the bolts.

8 The height of the lid in relation to the body can be adjusted by loosening the latch striker, repositioning the striker and retightening the bolts (see illustration).

22 Tailgate, station wagon - removal and refitting

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Open the tailgate and support it with a prop rod.

3 Place protective pads along the edges of the liftgate opening to prevent damage to the painted surfaces while work is being performed.

4 Remove the trim panel by carefully prising out the clips with a putty knife or a flat screwdriver.

5 Disconnect and remove all wiring from the tailgate.

6 Remove the washer hose if necessary. Prise the washer nozzle out and pull the hose from it. Pull the disconnected hose out from the tailgate.

7 Detach the liftgate supports from the tailgate (see Section 11) and support the tailgate in the fully open position.

8 Get an assistant to hold the tailgate while you remove the hinge pins You will have to take off the clips from the ends of the pins first.

9 Remove the tailgate and carefully store it out of the way.

10 Refitting is the reverse of removal.

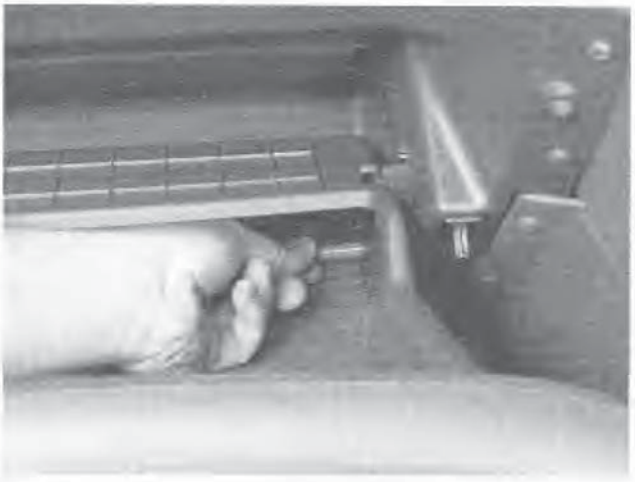
23 Instrument panel - removal and refitting

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by a notice on the driver's door and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires.*

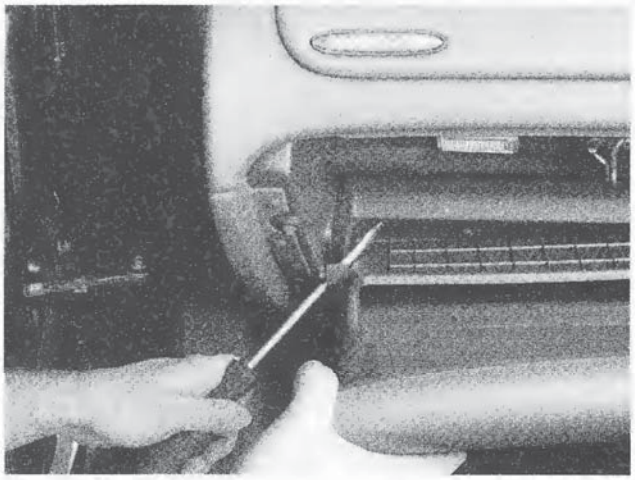
1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Disable the airbag system (see Chapter 12).



23.4a Prise the right hinge pin into the glove box



23.4b Using a flat-bladed screwdriver, prise the left side of the glove box out of the dash

23.4c Remove the insulation panel screws (arrows)

RIGHT SIDE LOWER COVER

3 Raise the steering column to the highest position. Grasp the top of the instrument panel lower cover, pull it back and use a flat-bladed screwdriver to prise out the left hinge pin. Remove the panel cover.

GLOVE BOX

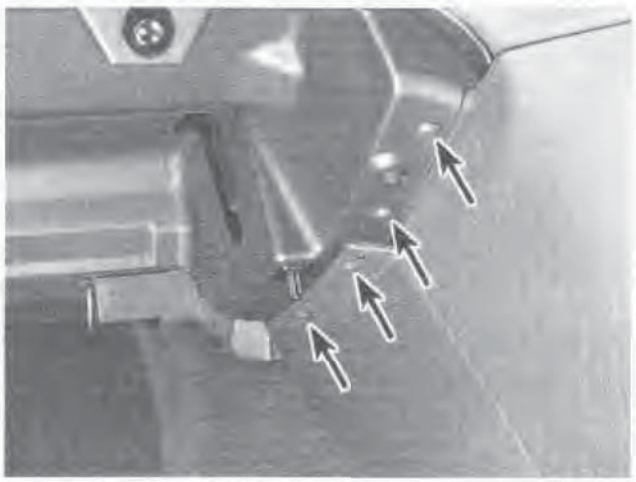
Refer to illustrations 23.4a, 23.4b and 23.4c

4 Open the glove box and prise the right hinge pin into the glove box (see illustration). Lower the right side of the glove box and detach the hinge from the left side (see illustration). Remove screws and detach the insulation panel from under the instrument panel on the passenger side (see illustration).

> **Note:** *On some models it will be necessary to depress the glove box door stops on each side of the glove box and allow the glove box door to move past the stops.*

5 Remove the centre console (see Section 20).

23.9a Remove the screws (arrows) securing the bottom of the centre fascia



23.9b Centre fascia upper retaining screws (arrows)

23.10 Carefully prise the upper centre trim facia up and out

23.14 Detach the upper footwell closing panel by pulling it down and to the left

6 Remove the radio (see Chapter 12) and the air conditioning control assembly (see Chapter 3).
7 Remove the steering column covers (see Section 24).
8 Remove the instrument cluster bezel (see Section 25)

CENTRE FASCIA

Refer to illustrations 23.9a, 23.9b and 23.10

9 On VX Series II and earlier, remove the screws and bolts and detach the centre fascia assembly (see illustrations).
10 On VY and later models, carefully prise the upper centre trim panel up and release the clips (see illustration).
11 Remove the radio assembly (see Chapter 12).
12 Remove the lower centre console as described earlier in this Chapter.
13 Remove the six mounting screws and remove the centre trim facia.

LEFT UPPER FOOTWELL CLOSING PANEL

Refer to illustration 23.14

14 Detach both sides of the panel, pulling it down and toward the left side, then lowering it from under the instrument panel (see illustration).

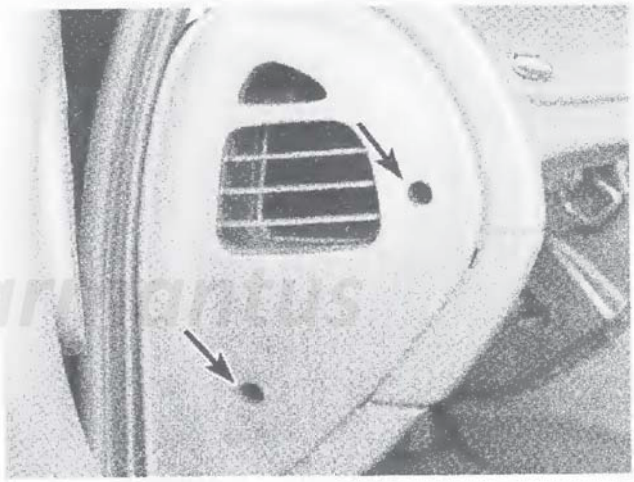
RIGHT UPPER FOOTWELL CLOSING PANEL

15 Remove the plastic screws and prise the retainer off, then lower the panel.
16 Remove the screws and detach the diagnostic connector.

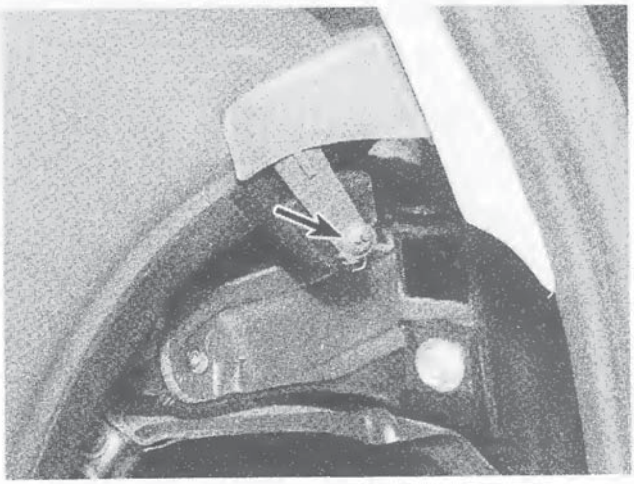
INSTRUMENT PANEL

Refer to illustrations 23.17, 23.20, 23.22, 23.23 and 23.26

17 Remove the air outlet housings from each end of the instrument panel (see illustration).
18 Unplug the body electrical harness.
19 Remove the steering wheel (see Chapter 10).
20 Remove the demister grilles from the top of the instrument panel (see illustration).
21 Remove the instrument panel radio speakers.

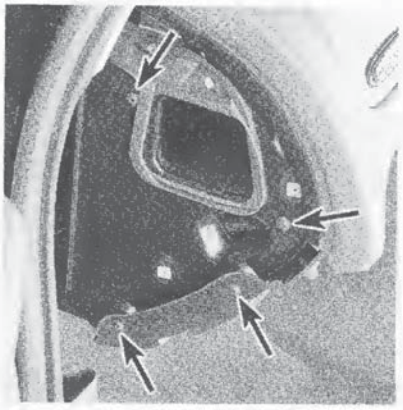


23.17 Remove the screws retaining the air outlet housings (arrows)

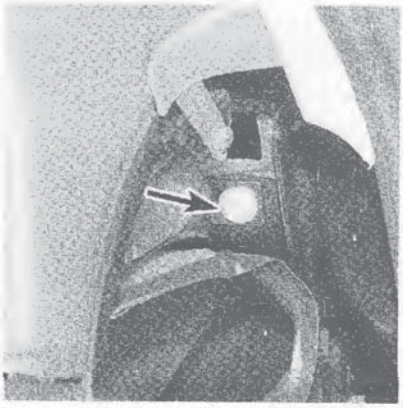


23.20 Remove the retaining screw (arrow) at each end, then remove the demister grilles

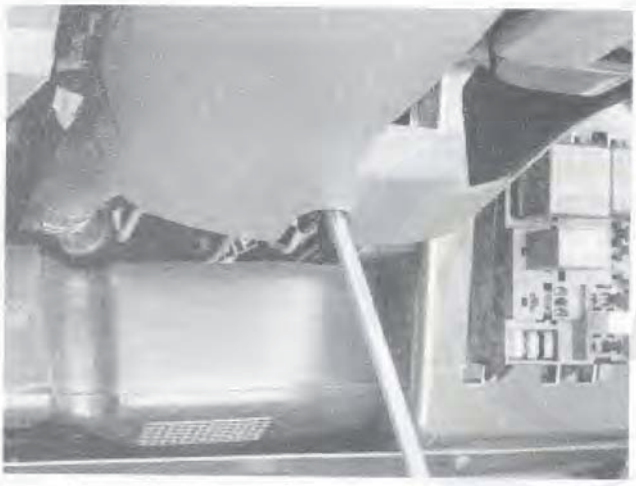
23.22 Remove the screws (arrows) retaining the front edge of the instrument panel to the body



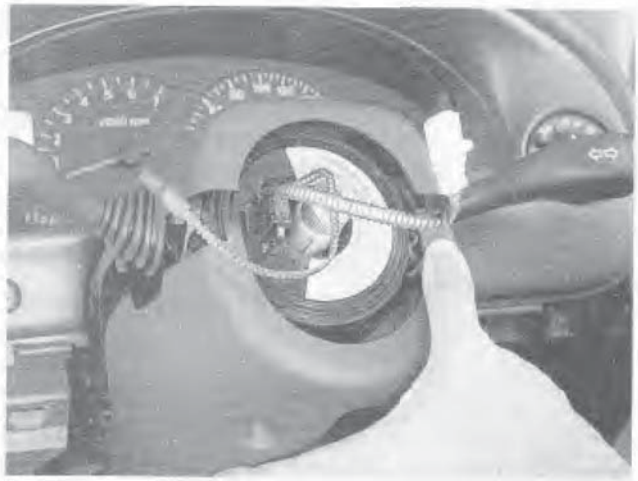
23.23 Remove the bolts and screws (arrows), then remove the brackets from the ends of the instrument panel



23.26 Remove the bolt (arrow) retaining each end of the instrument panel



24.3 Remove the steering column cover retaining screw and bolt



24.4 Rotate the rear of the upper cover up, then lift it off while pulling the lower cover rearward and down (steering wheel removed for clarity)

22 Remove the retaining screws along the front edge of the instrument panel (see illustration).

23 Remove the screws and brackets retaining the ends of the instrument panel to the body (see illustration).

24 Remove the instrument cluster (see Chapter 12).

25 Remove the steering column support bolts, then lower and support the steering column.

26 Remove the retaining bolt at each end of the instrument panel (see illustration). Pull the instrument panel out slightly and disconnect any electrical connectors connected to the panel.

27 Carefully remove the instrument panel from the vehicle.

28 Refitting is the reverse of removal.

24 Steering column cover - removal and refitting

Refer to illustrations 24.3 and 24.4

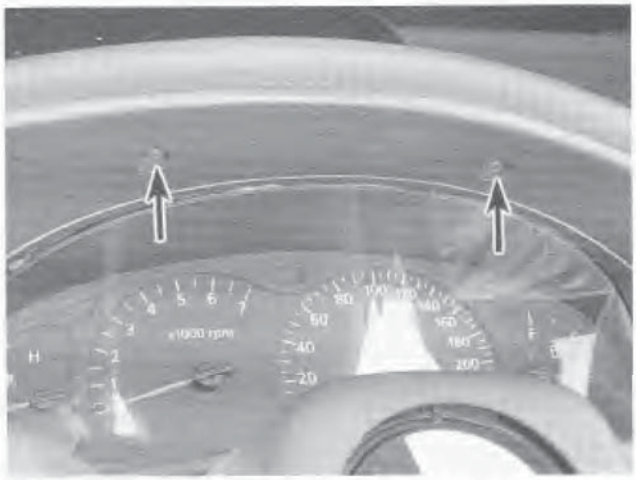
Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by a notice on the driver's door and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Raise the steering wheel to the upper position, grasp the upper edge of the steering column lower cover with both hands and pull down to detach the clips, then rotate it down out of the way.

3 Remove the column cover screw and bolt (see illustration).



25.3 Remove the two bezel screws (arrows) at the top and five screws along the lower edge of the bezel

25.4 Grasp the bezel securely and pull out sharply to detach it, then unplug the electrical connectors

4 Lower the steering column to its lowest position for access, then separate the covers and remove them (see illustration).

5 Refitting is the reverse of removal.

25 Instrument cluster bezel - removal and refitting

Refer to illustrations 25.3 and 25.4

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by a notice on the driver's door and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the steering column cover (see Section 24).

3 Remove the bezel retaining screws (see illustration).

4 Grasp the bezel securely and pull out sharply to detach the clips (see illustration).

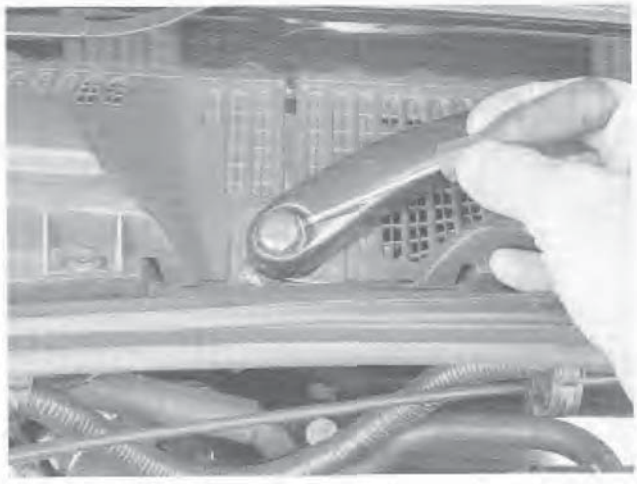
5 Refitting is the reverse of removal.

26 Cowl grille - removal and refitting

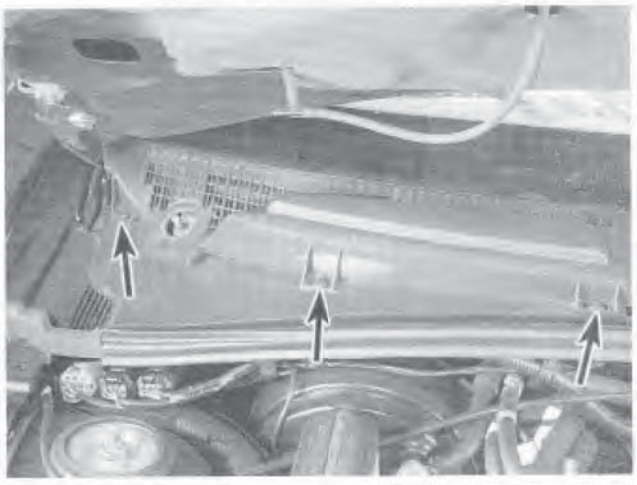
Refer to illustrations 26.1, 26.2 and 26.3

1 Remove the windscreen wiper arms (see illustration).

2 Remove the six plastic screws on each cowl grille, then detach the grilles (see illustration).

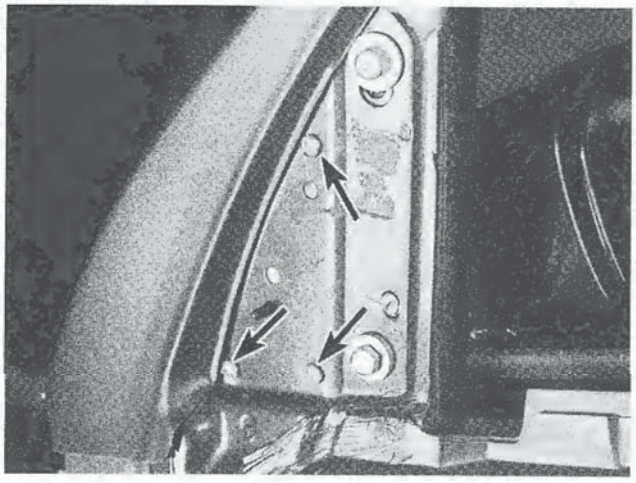


26.1 Prise out the cap with a small screwdriver and remove the nut, then detach the wiper arm



26.2 Each half of the cowl grille is held in place by three plastic rivets (arrows)

26.3 Use a phillips screwdriver to remove the plastic rivets, then detach the water deflector



27.3 Remove the three screws (arrows) and lift the mirror assembly off

3 Remove the ten plastic screws retaining the water deflector, then detach the deflector and lift it out (see illustration).

4 Refitting is the reverse of removal.

27 Outside mirror - removal and refitting

Refer to illustration 27.3

1 Disconnect the earth (-) lead from the battery.

> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Carefully prise off the mirror trim cover and pull the demister duct up out of the door.

3 Remove the mirror assembly retaining screws, pull the mirror out and unplug the wiring connector (see illustration).

4 Refitting is the reverse of removal.

28 Seats - removal and refitting

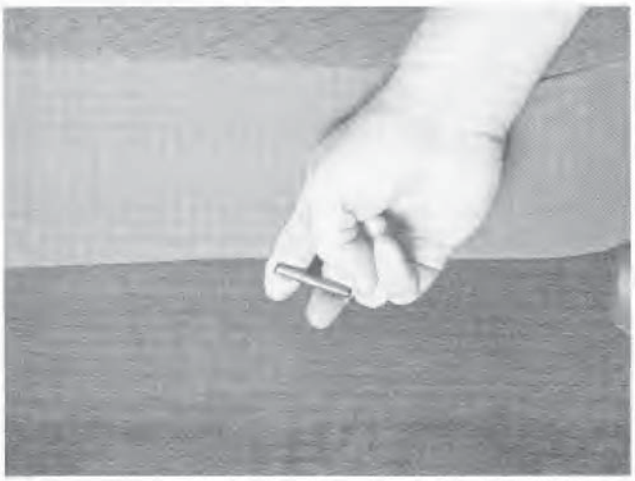
Refer to illustrations 28.1, 28.2, 28.5 and 28.6

> ***Warning:*** *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by a notice on the driver's door and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires.*

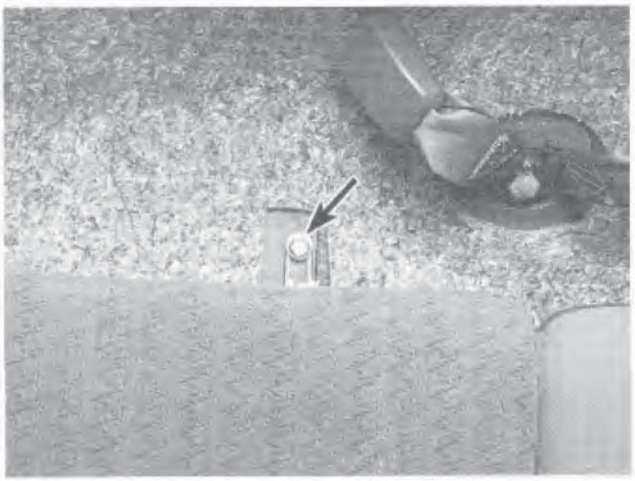
> ***Caution:*** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

28.1 Prise off the cover for access to the rear bolts on the front seat

28.2 The front bolts for the front seats can be removed with the seat moved rearward



28.5 Pull down on the release handles at each lower corner to release the seat cushion



28.6 Remove each of the seat back retaining bolts (arrow)

FRONT SEATS

1 Slide the seat forward for access to the rear bolts (see illustration). Remove the rear bolts.
2 Slide the seat rearward for access to the front bolts (see illustration). Remove the front bolts.
3 Disconnect any wiring for power seats.
4 Carefully remove the seat.

REAR SEAT CUSHION, SEDAN AND STATION WAGON

5 Disengage the rear seat cushion by pulling downward on the handle to release the mechanism on each side while lifting up on the cushion (see illustration). Detach the cushion and lift it from the vehicle.

REAR SEAT BACK, SEDAN

6 Remove the two bolts at the lower edge of each seat back, then detach the seat backs from the retaining brackets at the upper edge and lift them out (see illustration).
7 Refitting is the reverse of the removal procedure.

REAR SEAT BOLSTERS, STATION WAGON

8 Lower the seat back.
9 Use needle nose pliers to squeeze the retaining tangs together, rotate the bolster out and lift it from the seat back.
10 Refitting is the reverse of the removal procedure.

REAR SEAT BACK, STATION WAGON

11 Remove rear seat bolsters. Remove the two bolts at the lower edge of the seat back, then unlatch and lower the seat back.
12 Insert a screwdriver into the seat back retainer locking plate and pin assembly, then carefully prise them apart to withdraw the pins from the plate.
13 Lift the outer end of the seat up and out of the back retainer, then pull the seat back toward the door and withdraw it from the centre hinge assembly.
14 The seat must only be refitted in the lowered position. It can then be unfolded into the upright position so the locking plate and pin assembly will properly lock into place.

29 Tailgate and handle (utility models) - removal and refitting

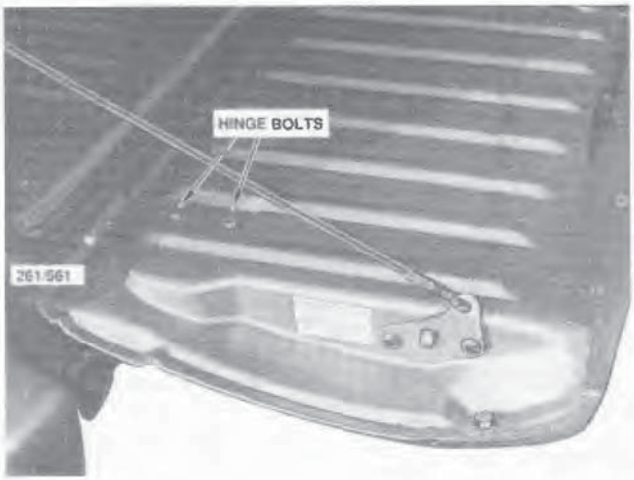
TAILGATE

Refer to illustration 29.3

1 Operate the tailgate lock release handle and lower the tailgate.
2 Support the tailgate on padded stands and disconnect the limit cables from each end of the tailgate.
3 Remove the tailgate hinge retaining bolts (see illustration).
4 Remove the tailgate from the vehicle.
5 Refitting is the reverse of removal. Tighten all hinge bolts securely.

HANDLE AND LOCK ASSEMBLY

6 Operate the tailgate lock release handle and lower the tailgate.



29.3 Location of the tailgate hinge retaining bolts

7 Support the tailgate on padded stands and disconnect the limit cables from each end of the tailgate.
8 Remove the release handle screw and remove the release handle from the lock shaft.
9 Remove the retaining screws and remove the cover surrounding the lock shaft from the tailgate.
10 Disconnect the retaining clips from the operating rods and lift the rods out of the lock lever.
11 Remove the retaining screws from the limit cable brackets and remove the brackets and operating rods from the tailgate.
12 Holding the lock shaft to avoid dropping the lock mechanism inside the tailgate, remove the lock mechanism retaining screws and manoeuvre the lock mechanism out of the tailgate.
13 Lubricate all moving and sliding surfaces with lithium based grease prior to refitting.
14 Refitting is the reverse of removal. Ensure that the operating rods enter from the top of the lock lever and lock the retaining clips securely. Tighten all retaining screws securely.

Chapter 12
Chassis electrical system

Contents

1 General information

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

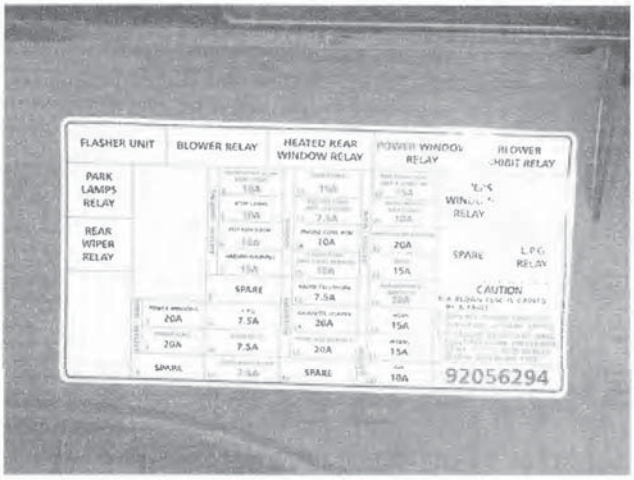
The electrical system is a 12-volt, negative earth type. Power for the lights and all electrical accessories is supplied by a lead/acid-type battery which is charged by the alternator.

This Chapter covers repair and service procedures for the various electrical components not associated with the engine. Information on the battery, alternator, ignition system and starter motor can be found in Chapter 5. It should be noted that when portions of the electrical system are serviced, the negative battery cable should be disconnected from the battery to prevent electrical shorts and/or fires.

2 Electrical troubleshooting - general information

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

3.1a The main fuse block is beneath the steering column. Grasp the upper edge of the cover and rotate it down for access to the fuse block



3.1b The fuse, relay and other electrical component locations are printed on a label on the steering column cover

A typical electrical circuit consists of an electrical component, any switches, relays, motors, fuses, fusible links or circuit breakers related to that component and the wiring and electrical connectors that link the component to both the battery and the chassis. To help you pinpoint an electrical circuit problem, wiring diagrams are included at the end of this book.

Before tackling any troublesome electrical circuit, first study the appropriate wiring diagrams to get a complete understanding of what makes up that individual circuit. Trouble spots, for instance, can often be narrowed down by noting if other components related to the circuit are operating properly. If several components or circuits fail at one time, chances are the problem is in a fuse or earth connection, because several circuits are often routed through the same fuse and earth connections.

Electrical problems usually stem from simple causes, such as loose or corroded connections, a blown fuse, a melted fusible link or a bad relay. Visually inspect the condition of all fuses, wires and connections in a problem circuit before troubleshooting it.

If testing instruments are going to be utilised, use the diagrams to plan ahead of time where you will make the necessary connections in order to accurately pinpoint the trouble spot.

The basic tools needed for electrical troubleshooting include a circuit tester or voltmeter (a 12-volt bulb with a set of test leads can also be used), a continuity tester, which includes a bulb, battery and set of test leads, and a jumper wire, preferably with a circuit breaker incorporated, which can be used to bypass electrical components. Before attempting to locate a problem with test instruments, use the wiring diagram(s) to decide where to make the connections.

VOLTAGE CHECKS

Voltage checks should be performed if a circuit is not functioning properly. Connect one lead of a circuit tester to either the negative battery terminal or a known good earth. Connect the other lead to an electrical connector in the circuit being tested, preferably nearest to the battery or fuse. If the bulb of the tester lights, voltage is present, which means that the part of the circuit between the electrical connector and the battery is problem free. Continue checking the rest of the circuit in the same fashion. When you reach a point at which no voltage is present, the problem lies between that point and the last test point with voltage. Most of the time the problem can be traced to a loose connection.

> ***Note:*** *Keep in mind that some circuits receive voltage only when the ignition key is in the Accessory or Run position.*

FINDING A SHORT

One method of finding shorts in a circuit is to remove the fuse and connect a test light or voltmeter in its place to the fuse terminals. There should be no voltage present in the circuit. Move the wiring harness from side-to-side while watching the test light. If the bulb goes on, there is a short to earth somewhere in that area, probably where the insulation has rubbed through. The same test can be performed on each component in the circuit, even a switch.

EARTH CHECK

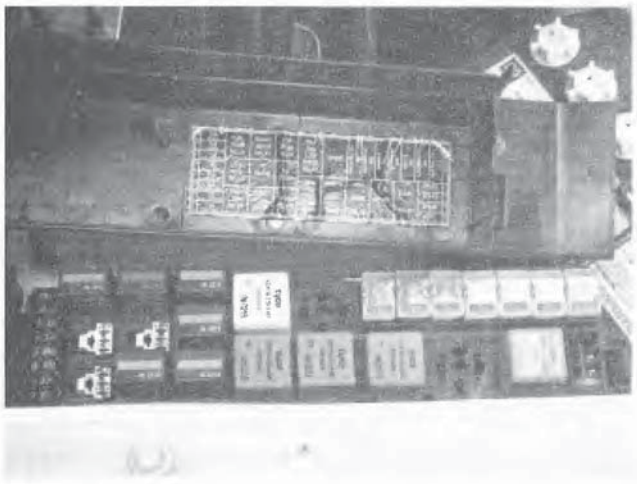
Perform an earth test to check whether a component is properly earthed. Disconnect the battery and connect one lead of a self-powered test light, known as a continuity tester, to a known good earth. Connect the other lead to the wire or earth connection being tested. If the bulb goes on, the earth is good. If the bulb does not go on, the earth is not good.

CONTINUITY CHECK

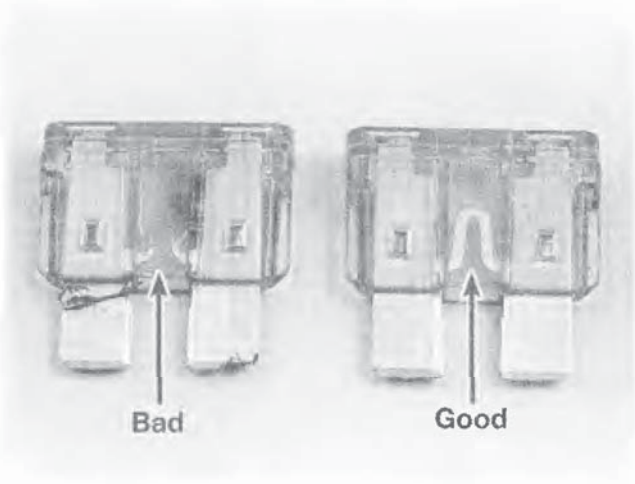
A continuity check is done to determine if there are any breaks in a circuit - if it is passing electricity properly. With the circuit off (no power in the circuit), a self-powered continuity tester can be used to check the circuit. Connect the test leads to both ends of the circuit (or to the "power" end and a good earth), and if the test light comes on, the circuit is passing current properly. If the light doesn't come on, there is a break somewhere in the circuit. The same procedure can be used to test a switch, by connecting the continuity tester to the switch terminals. With the switch turned On, the test light should come on.

FINDING AN OPEN CIRCUIT

When diagnosing for possible open circuits, it is often difficult to locate them by sight because oxidation or terminal misalign-



3.1c You will find the secondary electrical centre under the bonnet. It also houses fusible links and relays



3.3 A blown fuse can be easily recognised by checking for the broken internal conductor

ment are hidden by the electrical connectors. Merely wiggling an electrical connector on a sensor or in the wiring harness may correct the open circuit condition. Remember this when an open circuit is indicated when troubleshooting a circuit. Intermittent problems may also be caused by oxidised or loose connections.

Electrical troubleshooting is simple if you keep in mind that all electrical circuits are basically electricity running from the battery, through the wires, switches, relays, fuses and fusible links to each electrical component (light bulb, motor, etc.) and to earth, from which it is passed back to the battery. Any electrical problem is an interruption in the flow of electricity to and from the battery.

3 Fuses - general information

Refer to illustrations 3.1a, 3.1b, 3.1c and 3.3

1 The electrical circuits of the vehicle are protected by a combination of fuses, circuit breakers and fusible links. There are two fuse blocks. The main one is located beneath the cover in the lower right side of the instrument panel under a cover (see illustrations). To open the panel, move the steering column to the upper position, then grasp the top corners of the instrument panel lower cover and pull it down. There is also a fuse block in the right front corner of the engine compartment which contains most of the relays as well as some fusible links (see illustration). The vehicles covered by this manual use modern plastic fuses.

2 Each of the fuses is designed to protect a specific circuit, and the various circuits are identified on the fuse panel itself.

3 If an electrical component fails, always check the fuse first. A blown fuse is easily identified through the clear plastic body. Visually inspect the element for evidence of damage (see illustration). If a continuity check is called for, check from terminal to terminal with an ohmmeter or wire it in series with a test light connected to the battery.

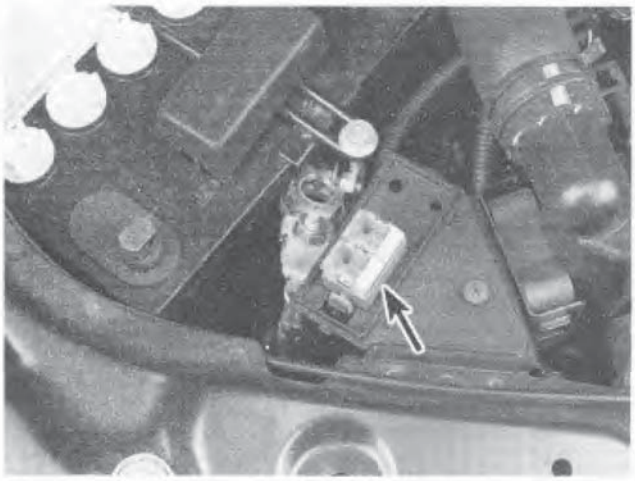
4 Be sure to renew blown fuses with the correct type. Fuses of different ratings are physically interchangeable, but only fuses of the proper rating should be used. Renewing a fuse with one of a higher or lower value than specified is not recommended. Each electrical circuit needs a specific amount of protection. The amperage value of each fuse is stamped into the fuse body. If the renewal fuse immediately fails, don't renew it again until the cause of the problem is isolated and corrected. In most cases, the cause will be a short circuit in the wiring caused by a broken or deteriorated wire.

4 Fusible links - general information

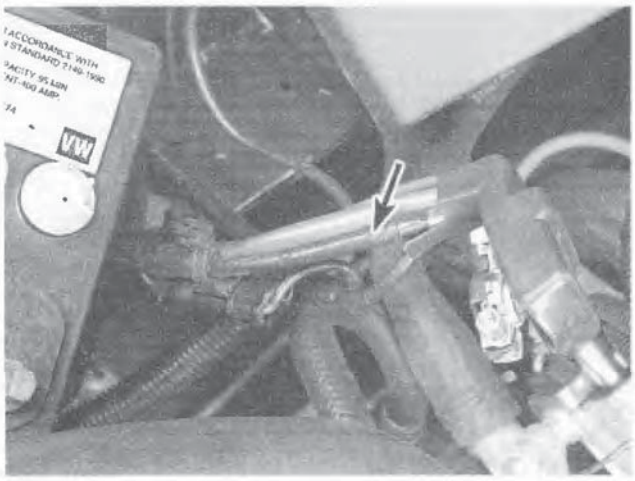
Refer to illustrations 4.1, 4.2a and 4.2b

The models covered by this manual use both wire-type and plug-in type fusible links. Several plug-in type fusible links are located in a holder adjacent to the engine compartment fuse box (see illustration 3.1c). These can be tested and renewed much like a large fuse. Some of these are retained by a bolt which must first be removed (see illustration).

4.1 The fusible links are mounted in the engine compartment adjacent to the fuse block. The main fusible link is retained by a bolt (arrow)



4.2a The cooling fan fusible links (arrow) are located next to the battery earth cable



4.2b The battery positive cable harness contains a wire-type fusible link (arrow)

The cooling fans are protected by two fusible links near the battery earth cable (see illustration). There are also two wire-style fusible links (with gauges smaller than the wire it is designed to protect) in the positive battery cable harness (see illustration).

Wire fusible links cannot be repaired, but a new link of the same size wire can be put in its place. The procedure is as follows:

a) Disconnect the negative cable from the battery.
b) Disconnect the fusible link from the wiring harness.
c) Fit the new fusible link.
d) Connect the battery earth cable. Test the circuit for proper operation.

5 Circuit breakers - general information

Circuit breakers may be used to protect some components such as power windows, power door locks and headlights.

On some models the circuit breaker resets itself automatically, so an electrical overload in a circuit breaker protected system will cause the circuit to fail momentarily, then come back on. If the circuit doesn't come back on, check it immediately. Once the condition is corrected, the circuit breaker will resume its normal function. Some circuit breakers must be reset manually.

6 Relays - general information and testing

GENERAL INFORMATION

1 Several electrical accessories in the vehicle, such as the fuel injection system, power windows, power door locks and air conditioning use relays to transmit the electrical signal to the component. Relays use a low-current signal (the control circuit, which is opened and closed by the circuit's switch) to turn the high-current flow in the main circuit on and off. If the relay is defective, that component will not operate properly.

2 Some relays are grouped together in the engine compartment fuse box. There are others near the fuse centre under the steering column.

3 If a faulty relay is suspected, it can be removed and tested using the procedure below or by a dealer service department or a repair shop. Defective relays must be renewed as a unit.

TESTING

4 It's best to refer to the wiring diagram for the circuit to determine the proper hook-ups for the relay you're testing. However, if you're not able to determine the correct hook-up from the wiring diagrams, you may be able to determine the test hook-ups from the information that follows. The relays used are all of the four or five terminal design.

RELAYS WITH FOUR TERMINALS

5 On most relays with four terminals, two of the four terminals are for the relay's control circuit (they connect to the relay's coil which, when energised, closes the large contacts to complete the circuit). The other two terminals are for the relay's power circuit (they are connected together within the relay when the control-circuit coil is energised).

6 Relays are sometimes marked as an aid to help you figure out which two terminals are for the control circuit and which are for the power circuit. As a general rule, the two thicker wires connected to the relay are for the power circuit; the two thinner wires are for the control circuit.

7 Remove the relay from the vehicle and check for continuity between the relay's power circuit terminals. There should be no continuity.

8 Connect a fused jumper wire between one of the two control circuit terminals and the positive battery terminal. Connect another jumper wire between the other control circuit terminal and earth. When the connections are made, the relay should click. On some relays, polarity may be critical, so, if the relay doesn't click, try swapping the jumper wires on the control circuit terminals.

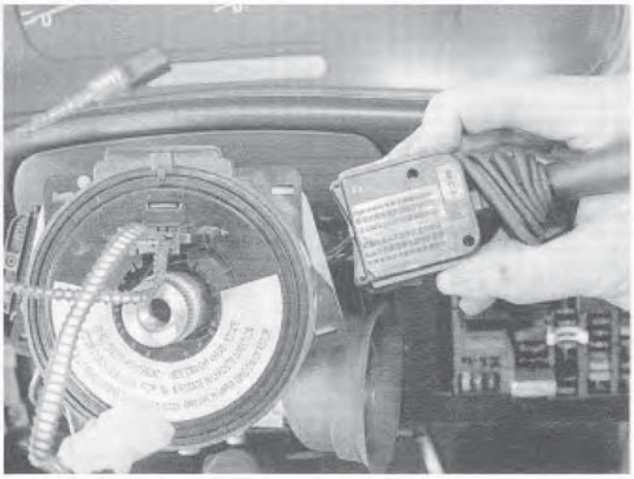
9 With the jumper wires connected, check for continuity between the power circuit terminals. Now there should be continuity.

10 If the relay fails any of the above tests, renew it.

RELAYS WITH FIVE TERMINALS

11 If the relay has five terminals, it's best to check the wiring diagram to determine which terminals connect to which of the relay's components.

12 Often it is easiest and fastest to simply renew a relay that does not click.



8.3 Depress the tangs to extract the turn signal switch from the column

7 Turn signal/hazard flasher - check and renewal

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

Note: *The wiring diagrams at the end of this Chapter may help with the following checks. Keep in mind that power wires are generally larger in diameter and brighter colours, where earth wires are usually smaller in diameter and darker colours. When checking for voltage, the probe of an earthed 12-volt test light may be touched to each terminal at a connector until it lights; this verifies voltage (power) at that terminal.*

1 The flasher - a small unit located under the dash in the left upper corner of the fuse block under the steering column - flashes the turn signals and warning lights (see illustrations 3.1a and 3.1b). Access the flasher by lowering the panel at the right of the steering column. Rotate the upper clips to do so.

2 When the flasher unit is functioning properly, a click can be heard during its operation. If the turn signals fail on one side or the other and the flasher unit does not make its characteristic clicking sound, a faulty turn signal bulb is indicated.

3 If both turn signals fail to blink, the problem may be due to a blown fuse, a faulty flasher unit, a broken switch or a loose or open connection. If a quick check of the fuse box indicates that the turn signal fuse has blown, check the wiring for a short before fitting a new fuse.

4 To renew the flasher, simply unplug it and pull it out of the clip.

5 Make sure that the renewal unit is identical to the original. Compare the old one to the new one before fitting it.

6 Refitting is the reverse of removal.

8 Turn signal switch - removal and refitting

Refer to illustration 8.3

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

1 Disconnect the negative battery cable and remove the steering wheel (see Chapter 10 for procedure including air bag removal).

2 Remove the covers from the steering column (see Chapter 11).

3 Press in on the locking clips and pull the switch out partly (see illustration).

4 Disconnect the wiring from the switch and pull the switch out all the way.

5 Refitting is the reverse of removal.

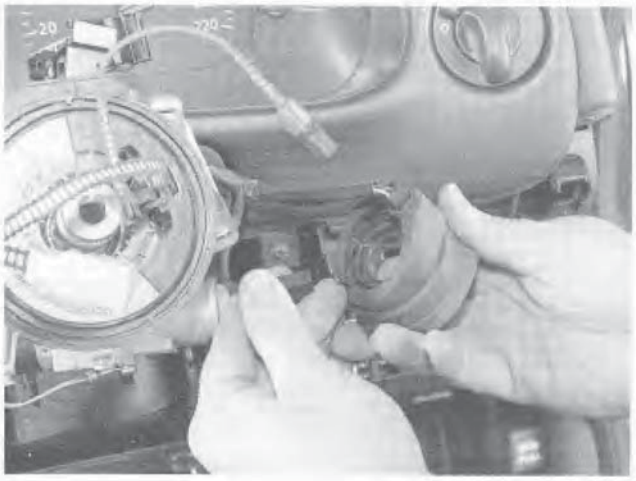
9 Headlight switch - check and renewal

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

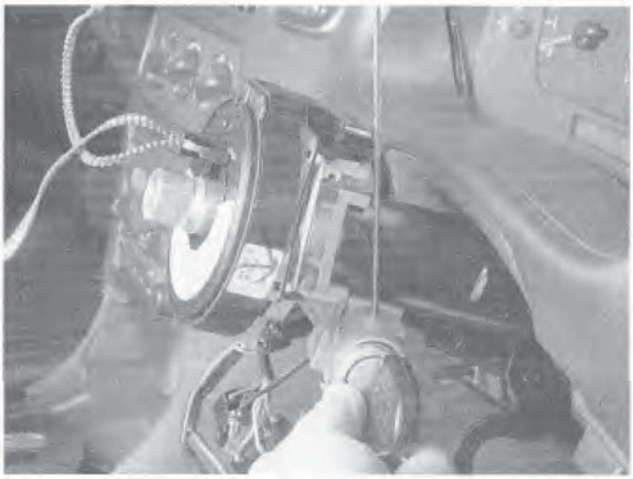
CHECK

1 Check the headlight circuit fuses and relay first (see Section 3).

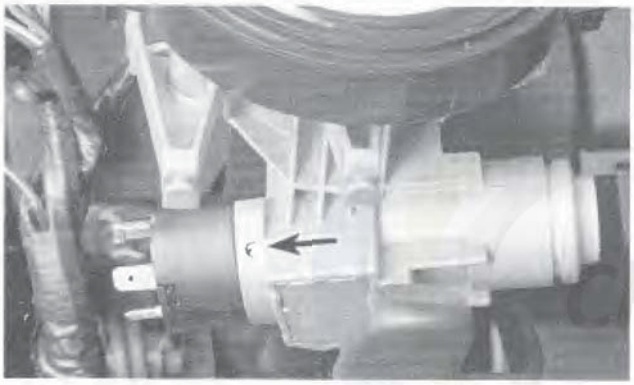
2 If the fuses and relay are OK, disconnect the negative battery cable and remove the headlight switch (see below).



10.3 Pull the key reader collar out and unplug the bulb and socket



10.5 With the key in the On position, insert an Allen wrench or other thin tool into the release pin hole to release the lock cylinder



10.8 Remove the screw (arrow) with a small screwdriver, then withdraw the ignition switch from the housing

3 To check the headlight/parking light on/off function, reconnect the headlight switch and battery and check for power into and out of the switch. If there's power to the switch but no power out to the lights, renew the switch. If there's power into and out of the switch, the switch is probably good. If there's no power to the switch, there's a problem in the wiring harness to the switch.

RENEWAL

4 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

5 On VT to VX models, the headlight switch is part of the instrument cluster bezel. It is necessary to remove the entire bezel assembly, then remove the headlight switch from that unit. On VY and VZ models, it is still necessary to remove the instrument cluster bezel to allow access to the rear of the head light switch.

6 Remove the screws that secure the instrument cluster bezel (see Chapter 11).

7 On VT to VX models, pull the bezel out far enough to disconnect the wiring. Depress the retainer on the electrical connector and remove the headlight switch from the assembly.

8 On VY to VZ models, remove the bezel entirely, reach in behind the headlamp switch and push the rear of the switch toward the driver seat, disengaging the retaining clips. Pull the switch through until the wiring can be disconnected.

9 Refitting is the reverse of removal.

10 Ignition switch/key lock cylinder - removal and refitting

Refer to illustrations 10.3, 10.5 and 10.8

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the steering column covers. Refer to Chapter 11 if necessary.

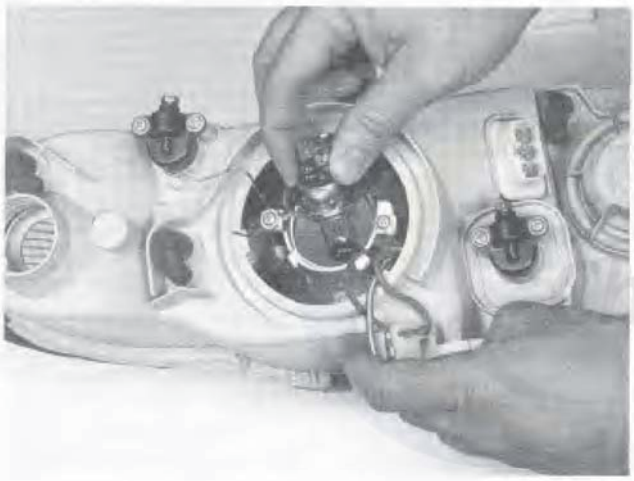
3 Unplug the wiring connector and remove the bulb and socket, then detach the key reader collar from the lock cylinder (see illustration).

4 Turn the key to ON.

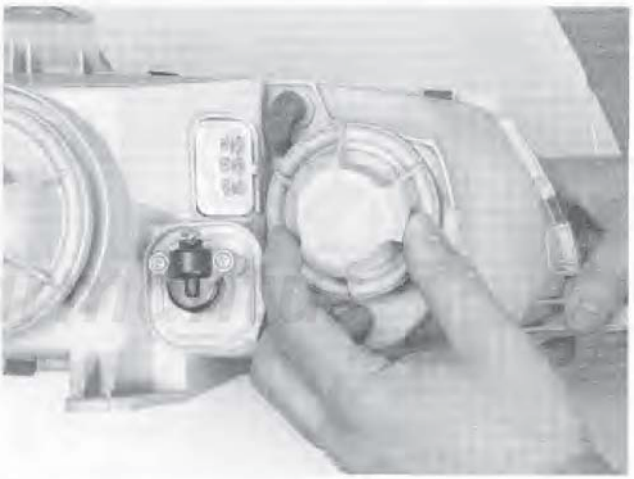
5 Push an Allen wrench or a similar long, thin tool of about 3 mm into the hole in the lock to release the key lock cylinder (see illustration).

11.2 Remove the headlight bulb cover by rotating it anti-clockwise

11.4a Detach the retaining clip from the rear of the headlight housing



11.4b Withdraw the bulb holder. Don't touch the bulb with your fingers



11.6 Remove the inboard high beam bulb cover

6 Pull out the cylinder by the key.
7 Disconnect the wiring from the ignition switch.
8 Remove the switch screw (see illustration) and disengage the roll-pin as you pull the switch out.
9 Refitting is the reverse of removal. The key will have to be in the ON position when the lock cylinder is inserted. Make sure that the switch registers correctly with the shaft as it is refitted.

11 Headlight bulbs - renewal

Warning: *Halogen bulbs are gas-filled and under pressure and may shatter if the surface is scratched or the bulb is dropped. Wear eye protection and handle the bulbs carefully, grasping only the base whenever possible. Don't touch the surface of the bulb with your fingers because the oil from your skin could cause it to overheat and fail prematurely. If you do touch the bulb surface, clean it with isopropyl alcohol.*

1 It may be necessary to remove the battery for access to the driver's side headlights.

HEADLIGHT BULB

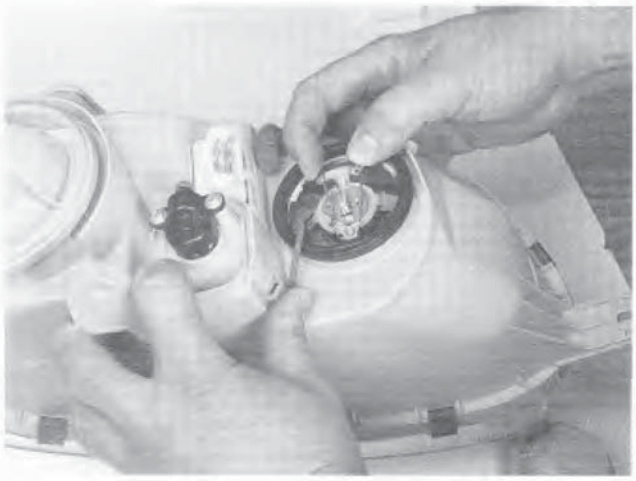
Refer to illustrations 11.2, 11.4a and 11.4b

2 Unscrew the cover from the rear of the headlight (see illustration).
3 Pull the wiring harness from the bulb.
4 Remove the retainer spring, then remove the bulb (see illustrations).
5 Refitting is the reverse of removal.

INBOARD HIGH BEAM BULB

Refer to illustrations 11.6, 11.8a and 11.8b

6 Unscrew the cover from the rear of the headlight (see illustration).



11.8a Detach the retaining clip

11.8b Pull the bulb straight out of the opening

11.11 Unplug the connector (arrow). Push in and rotate the turn signal bulb holder to remove it

7 Pull the wiring harness from the bulb.
8 Remove the retainer spring, then pull the bulb straight out (see illustrations).
9 Refitting is the reverse of removal.

FRONT TURN SIGNAL BULB

Refer to illustration 11.11

10 The front turn signal bulb is adjacent to the headlight bulb.
11 Unplug the electrical connector (see illustration).
12 Push in and rotate the turn signal bulb to remove it.
13 Refitting is the reverse of removal.

PARKING LIGHT BULB

14 The parking lamp bulb is located in the headlight reflector.
15 Grasp the bulb holder and pull it out, then withdraw the bulb.
16 Refitting is the reverse of removal.

12 Headlights - adjustment

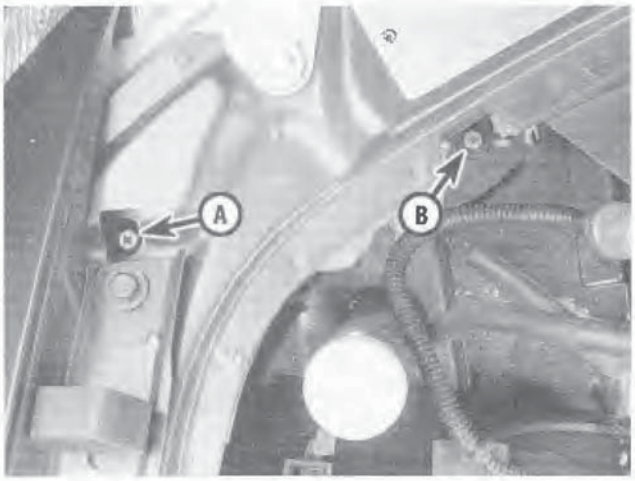
Refer to illustrations 12.1 and 12.2

Note: *The headlights must be aimed correctly. If adjusted incorrectly they could blind the driver of an oncoming vehicle and cause a serious accident or seriously reduce your ability to see the road. The headlights should be checked for proper aim every 12 months and any time a new headlight is refitted or front end body work is performed. It should be emphasised that the following procedure is only an interim step which will provide temporary adjustment until the headlights can be adjusted by a properly equipped shop.*

1 Sealed beam headlights have two adjusting screws, one controlling up-and-down movement and one controlling left-and-right movement (see illustration).
2 There are several methods of adjusting the headlights. The simplest method requires a blank wall 8 meters in front of the vehicle and a level floor (see illustration).
3 Position masking tape vertically on the wall in reference to the vehicle centreline and the centrelines of both headlights.
4 Position a horizontal tape line in reference to the centreline of all the headlights.

Note: *It may be easier to position the tape on the wall with the vehicle parked only a few centimetres away.*

5 Adjustment should be made with the vehicle sitting level, the fuel tank half-full and no unusually heavy load in the vehicle.
6 Starting with the low beam adjustment, position the high intensity zone so it's five centimetres below the horizontal line and five centimetres to the side of the headlight vertical line, away from oncoming traffic. Adjustment is made by turning the lower outer adjuster for the vertical adjustment and the inboard adjuster for the horizontal adjustment.
7 With the high beams on, the high intensity zone should be vertically centred with the exact centre just below the horizontal line.



12.1 The outboard adjustment screw (A) moves the headlight left-and-right and the inboard screw (B) moves it up-and-down

***Note:** It may not be possible to position the headlight aim exactly for both high and low beams. If a compromise must be made, keep in mind that the low beams are the most used and have the greatest effect on driver safety.*

8 Have the headlights adjusted by a dealer service department or service station at the earliest opportunity.

13 Headlight housing - removal and refitting

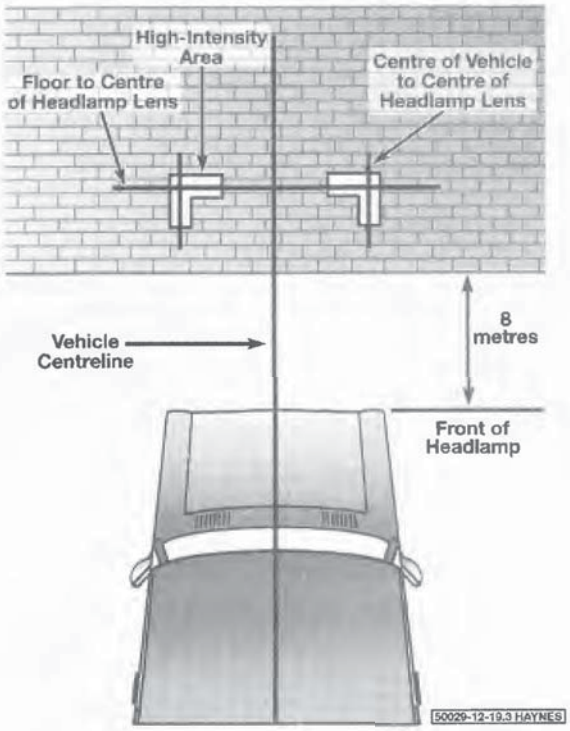
Refer to illustration 13.4

1 Disconnect the earth (-) lead from the battery.

***Caution:** On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Remove the grille. Refer to Chapter 11. On VY and VZ models, it may be necessary to remove the front bumper, or at least lower it to allow removal of the headlight housing. Refer to Chapter 11.

13.4 The headlight housing is held in place by two bolts at the top and one bolt (arrow) at the corner



12.2 A simple headlight adjustment can be done using a flat surface and a broad wall

3 Disconnect the wiring harnesses.

4 Remove the bolts that secure the headlight assembly to the front end (see illustration). Remove the headlight unit.

5 Refitting is the reverse of removal.

14 Bulb renewal

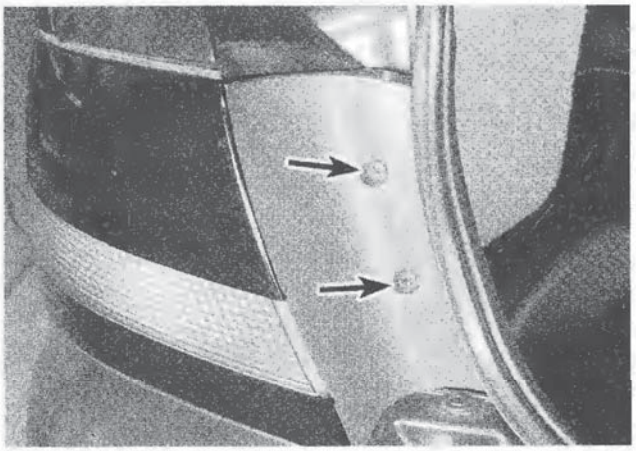
SIDE TURN SIGNAL

Refer to illustrations 14.1 and 14.2

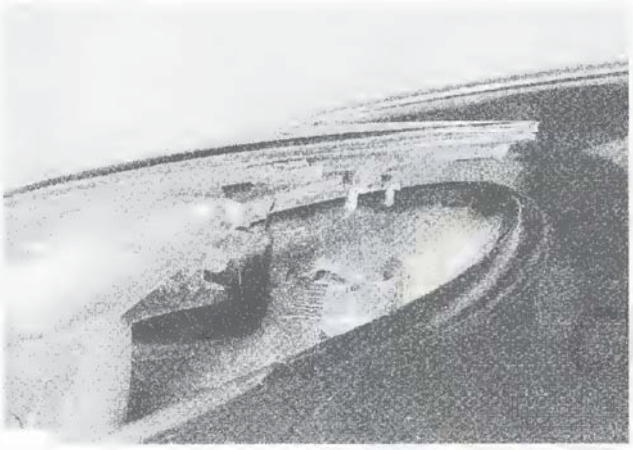
1 Grasp the rear edge of the housing securely and rotate it out for access to the bulb (see illustration).

14.1 Prise the rear edge out and rotate the side turn signal housing out of the body

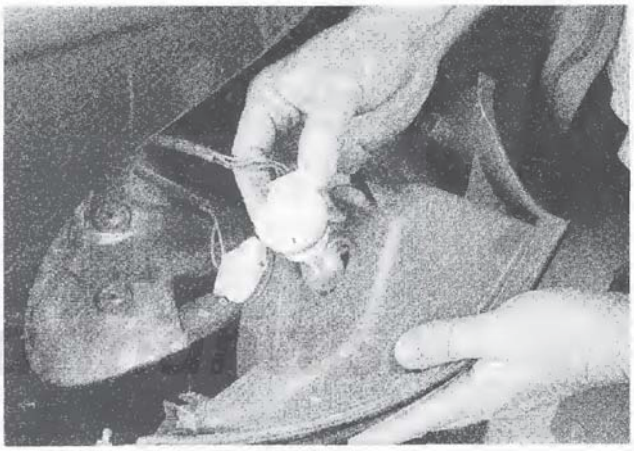
14.2 Rotate the bulb holder anti-clockwise, then withdraw it from the light housing



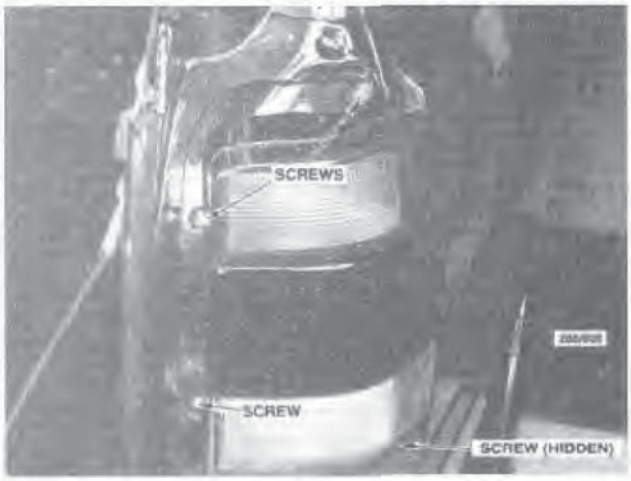
14.5a Remove the lamp housing screws (arrows)



14.5b Rotate the housing out for access to the bulb holders



14.5c Turn the bulb holders anti-clockwise to remove them



14.7 Typical rear tail lamp retaining screw location - utility models

2 Rotate the bulb holder anti-clockwise to remove it from the housing and pull the bulb straight out (see illustration).

3 Refitting is the reverse of removal.

TAIL, STOP AND TURN SIGNAL

Sedan

Refer to illustrations 14.5a, 14.5b, 14.5c and 14.7

4 Open the luggage compartment.

5 Remove the screws, rotate the lamp housing out for access and remove the bulb holders (see illustrations).

6 Refitting is the reverse of removal.

Station wagon and utility

7 Open the tailgate and on utility models, remove the tail lamp top cover panel retaining screws and withdraw the cover (see illustration). On station wagon models detach the trim panel.

8 Remove the bulb holder from the housing by rotating it anti-clockwise.

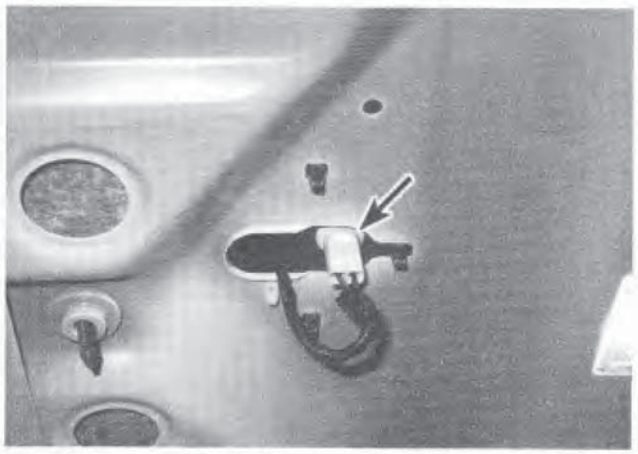
9 Refitting is the reverse of removal.

HIGH-MOUNTED STOP LIGHT

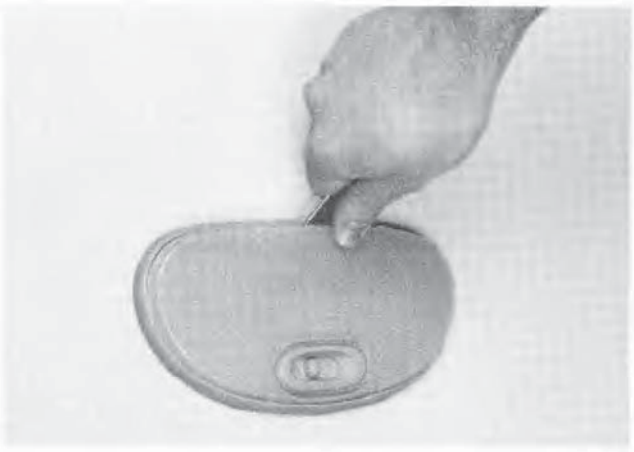
Sedan

Refer to illustration 14.11

10 Open the boot for access to the bulb holder located under the rear parcel shelf.

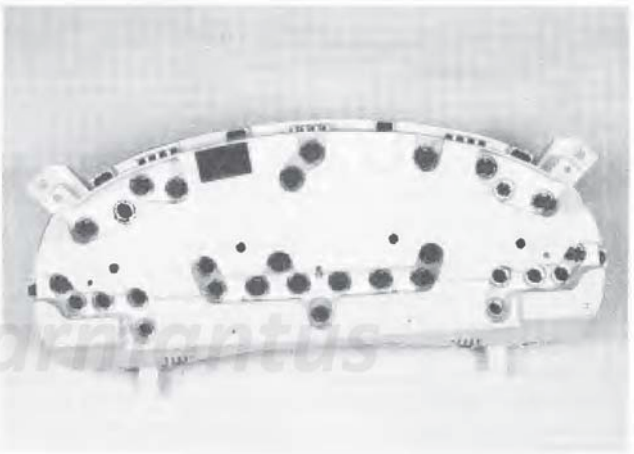


14.11 Rotate the high-mounted stop light holder (arrow) and lower it for access to the bulb



14.22 Use a small screwdriver to detach the interior light lens

14.23 Pull the bulb (arrow) from the terminals



14.27 Illumination for the dash instruments is provided by miniature bulbs. Remove the entire instrument cluster to renew them

11 Grasp the bulb socket securely and pull it straight down (see illustration).
12 Pull the bulb from the holder.
13 Refitting is the reverse of removal.

Station wagon

14 Open the tailgate, remove the two plastic screws and detach the high-mounted stop light cover.
15 Twist the bulb socket to detach it, then twist the bulb to remove it.
16 Refitting is the reverse of removal.

NUMBER PLATE LIGHT

Sedan

17 Remove the screws, detach the lens, then pull the bulb straight out of the socket.
18 Refitting is the reverse of removal.

Station wagon

19 Open the tailgate and use a small screwdriver to detach the left end of the bulb holder.
20 Remove the bulb socket and pull the bulb straight out.
21 Refitting is the reverse of removal.

INTERIOR LIGHT

Refer to illustrations 14.22 and 14.23

22 Use a small screwdriver to detach the lens (see illustration).
23 Spread the bulb terminals apart and detach the bulb (see illustration).
24 Refitting is the reverse of removal.

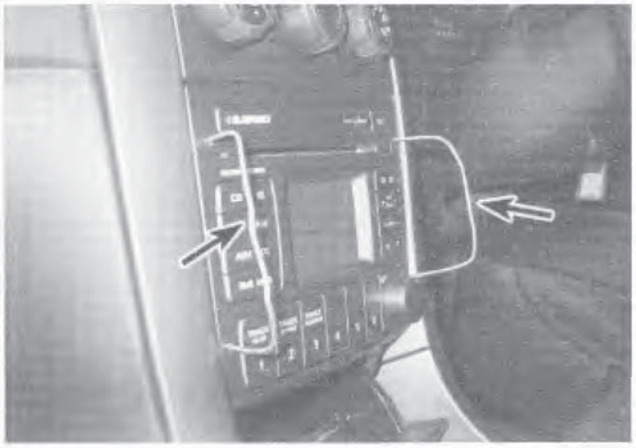
GLOVE COMPARTMENT LIGHT

25 Use a small screwdriver to carefully prise the housing out.
26 Spread the bulb terminals apart and detach the bulb.

INSTRUMENT CLUSTER BULBS

Refer to illustration 14.27

27 For access to the instrument panel lights, the instrument cluster will have to be removed first (see Section 18) (see illustration).
28 Refitting is the reverse of removal.



15.3 Insert the special tool or bent wires (arrows) into the release holes, flex them to the sides and slide the radio out (VY model shown)

15 Radio and speakers - removal and refitting

Refer to illustrations 15.3, 15.6 and 15.8

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

RADIO

Note: *Ensure there are no CDs in the audio unit before disconnecting the battery. There is a risk of damage to the audio unit and CD if the unit is removed without being emptied.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 On these models, the radio is retained in the instrument panel by special clips. Releasing these clips requires the use of two sets of Holden removal tool number 179 1308 000 for VT to VX models or KM6067 for VY and VZ models. Alternatively, two short lengths of wire can be bent into U-shapes. Insert the tools into the holes at the corners of the radio until you feel the internal clips release.

3 With the clips released, flex out simultaneously on both tools and pull the radio out of the instrument panel. Unplug the aerial and electrical connectors and remove the unit (see illustration).

4 Refit the radio by plugging in the electrical connectors, then sliding the radio unit along the tracks into the instrument panel until the clips can be felt snapping into place.

SPEAKERS

Instrument panel mounted

5 Remove the instrument panel front covers, the console, centre fascia, footwell panels, the steering wheel and the demister grilles (see Chapter 11).

6 Remove the screws securing the speaker (see illustration). Disconnect the wiring and remove the speaker.

Door mounted

7 Remove the door trim panel (see Chapter 11).

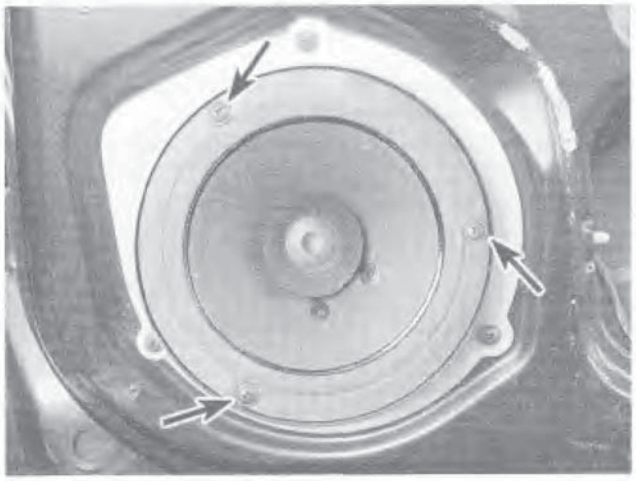
8 Remove the screws securing the speaker (see illustration). Disconnect the wiring and remove the speaker.

Parcel shelf mounted

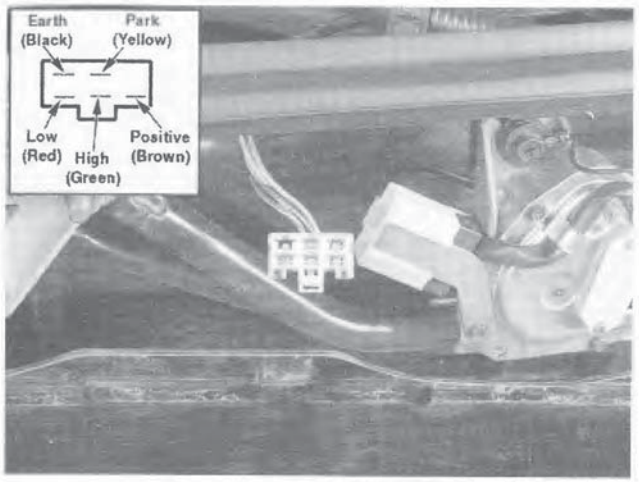
9 Remove the rear seat (see Chapter 11). Detach the parcel shelf.

10 Remove the screws and disconnect the wiring as you remove the speaker.

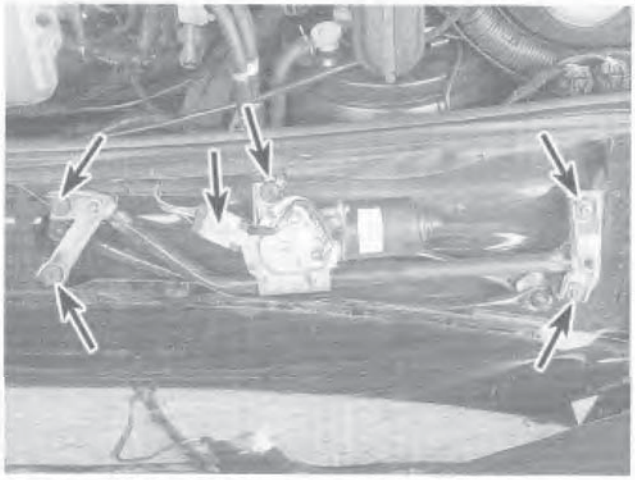
15.6 Remove the instrument panel mounted speaker screw (arrow)



15.8 Door mounted speaker screw locations (arrows)



16.2 Use a voltmeter or test light to check for voltage at the wiper motor



16.11 Wiper motor connection details

16 Windscreen wiper motor and circuit - check and renewal

Refer to illustrations 16.2 and 16.11

CHECK

> **Note:** *The wiring diagrams in this Chapter may help with the following checks. Keep in mind that power wires are generally larger in diameter and brighter colours, where earth wires are usually smaller in diameter and darker colours. When checking for voltage, the probe of an earthed 12-volt test light may be touched to each terminal at a connector until it lights; this verifies voltage (power) at the terminal.*

1 If the wipers work slowly, make sure the battery is in good condition and has a strong charge (see Chapter 1). If the battery is in good condition, remove the wiper motor (see below) and operate the wiper arms by hand. Check for binding linkage and pivots. Lubricate or repair the linkage or pivots as necessary. Refit the wiper motor. If the wipers still operate slowly, check for loose or corroded connections, especially the earth connection. If all connections look OK, renew the motor.

2 If the wipers don't work at all, check the fuse. If the fuse is OK, connect a jumper wire between the wiper motor and earth, then retest. If the motor works now, repair the earth connection. If the wipers still don't work, turn on the wipers and check for voltage at the motor (see illustration). If there's no voltage at the motor, remove the motor and check it off the vehicle with fused jumper wires from the battery. If the motor now works, check for binding linkage (see Step 1 above). If the motor still doesn't work, renew it. If there's no voltage at the motor, check for voltage at the switch. If there's no voltage at the switch, check the wiring between the switch and fuse panel for continuity. If the wiring is OK, the switch is probably bad.

3 If the wipers only work on one speed, check the continuity of the wires between the switch and motor. If the wires are OK, renew the switch.

4 If the interval (delay) function is inoperative, check the continuity of all the wiring between the switch and motor. If the wiring is OK, renew the interval module.

5 If the wipers stop wherever they are when the switch is turned off (fail to park), check for voltage at the wiper motor when the wiper switch is OFF but the ignition is ON. If voltage is present, the limit switch in the motor is malfunctioning. Renew the wiper motor. If no voltage is present, trace and repair the limit switch wiring between the fuse panel and wiper motor.

6 If the wipers won't shut off unless the ignition is OFF, disconnect the wiring from the wiper control switch. If the wipers stop, renew the switch. If the wipers keep running, there's a defective limit switch in the motor; renew the motor.

7 If the wipers won't retract, check for mechanical obstructions in the wiper linkage or on the vehicle's body which would prevent the wipers from retracting. If there are no obstructions, check the wiring between the switch and motor for continuity. If the wiring is OK, renew the wiper motor.

RENEWAL

8 Remove the wiper arms.

9 Remove the cowl and water shield for access to the wiper motor (see Chapter 11).

10 Disconnect the wiring from the motor.

11 Remove the mounting bolts and lift the motor and linkage assembly out (see illustration).

12 Prise the linkage arm from the motor with a screwdriver.

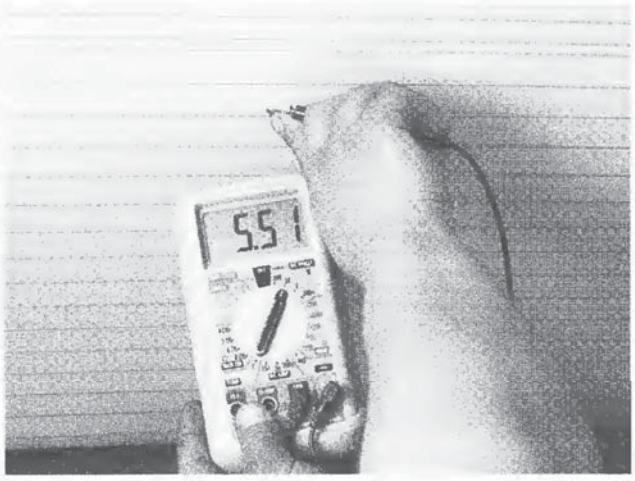
13 Refitting is the reverse of removal.

17 Rear window defogger - check and repair

1 The rear window defogger consists of a number of horizontal elements baked onto the glass surface.

2 Small breaks in the element can be repaired without removing the rear window.

17.4 When measuring voltage at the defogger grid, wrap a piece of tin foil around the negative probe of the voltmeter and press the foil against the wire with your finger



17.5 Check the voltage at the centre of each element. If it is six volts, it is good. If it is twelve volts, the element is broken between the centre and the positive end. If it is zero, it is broken between the element and negative end.

CHECK

Refer to illustrations 17.4, 17.5 and 17.7

3 Turn the ignition switch and defogger system switches to the ON position.

4 When measuring voltage during the next two tests, wrap a piece of aluminium foil around the tip of the voltmeter negative probe and press the foil against the heating element with your finger (see illustration). The positive probe must be connected to the 12 volt input source.

5 Check the voltage at the centre of each heating element (see illustration). If the voltage is 6-volts, the element is okay (there is no break). If the voltage is 12-volts, the element is broken between the centre of the element and the positive end. If the voltage is 0-volts the element is broken between the centre of the element and earth.

6 Connect the negative lead to a good body earth. The reading should stay the same.

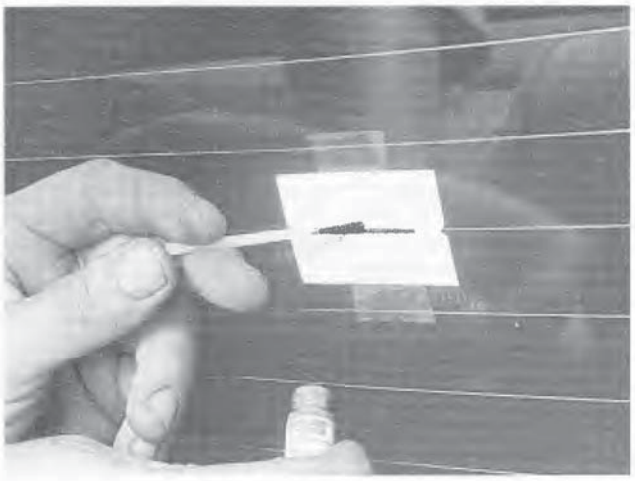
7 To find the break, place the voltmeter positive lead against the defogger positive terminal. Place the voltmeter negative lead with the foil strip against the heating element at the positive terminal end and slide it toward the negative terminal end. The point at which the voltmeter deflects from zero to several volts is the point at which the heating element is broken (see illustration).

REPAIR

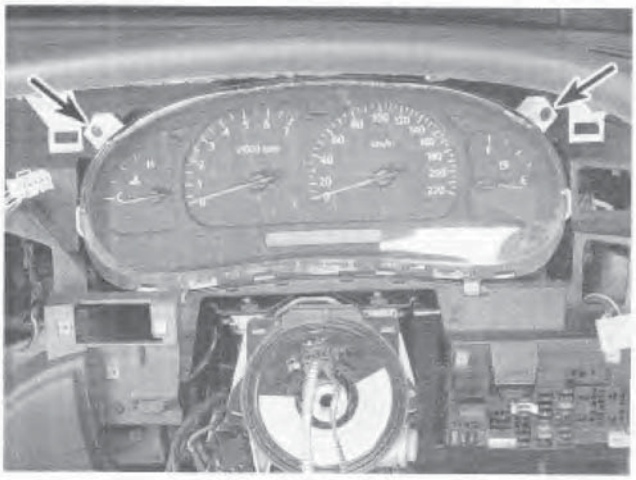
Refer to illustration 17.13

8 Repair the break in the element using a repair kit specifically recommended for this purpose, such as DuPont paste No. 4817 (or equivalent). Included in this kit is plastic conductive epoxy.

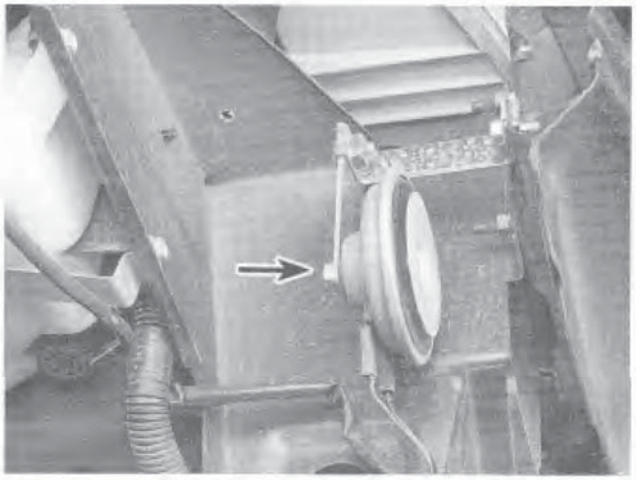
17.7 Slide the probe along the element. It is broken at the point where the voltmeter reading changes sharply



17.13 To use a defogger repair kit, apply masking tape to the inside of the window, then brush on the special conductive coating



18.6 These two screws (arrows) secure the instrument cluster



19.5 The entire front bumper assembly must be removed to access the horns (arrow)

9 Prior to repairing a break, turn off the system and allow it to cool off for a few minutes.
10 Lightly buff the element area with fine steel wool, then clean it thoroughly with isopropyl alcohol.
11 Use masking tape to mask off the area being repaired.
12 Thoroughly mix the epoxy, following the instructions provided with the repair kit.
13 Apply the epoxy material to the slit in the masking tape, overlapping the undamaged area about 18 mm on each end (see illustration).
14 Allow the repair to cure for 24 hours before removing the tape and using the system.

18 Instrument cluster - removal and refitting

Refer to illustration 18.6

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

1 Disconnect the earth (-) lead from the battery.

Caution: *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Lower the steering column to its lowest position for access to the steering column.
3 Remove the steering column cover (see Chapter 11).
4 Remove the cluster bezel (see Chapter 11).
5 Remove the screws and detach the bezel from the instrument panel.
6 Remove the two screws securing the instrument cluster and pull it out, disconnecting wires as you do so (see illustration).
7 Refitting is the reverse of removal.

19 Horn - check and renewal

Note: *Some models are equipped with a theft-deterrent system horn located at the upper rear of the engine compartment. The actual signal horns are located behind the front bumper.*

CHECK

1 Check the horn circuit fuse (see Section 3). If it is bad, renew it.
2 If the fuse is OK, check the relay. When the horn button is depressed, you should hear a faint click if the relay is functioning. To verify the relay is operating properly, test it (see Section 6).
3 To test the horn, unplug its electrical connector. Connect battery voltage to the two electrical terminals on the horn with a pair of fused jumper wires. If the horn doesn't sound, the horn is bad; renew it.
4 If the horn sounds during this test but does not sound when the horn button is depressed, the problem lies in the wiring, connections or horn switch.

RENEWAL

Refer to illustration 19.5

5 On most models, the complete front bumper assembly must be removed to get access to the horns (see illustration). Refer to Chapter 11 for the bumper removal procedure.
6 Disconnect the wiring from the horns and remove the mounting bolt.
7 Refitting is the reverse of removal.

20 Cruise control system - description and check

1 The cruise control system maintains vehicle speed with an electronic servo motor located in the engine compartment, which is connected to the throttle linkage by a cable, on models with a manually operated throttle. Or by signals sent through the engine management system to the electronic throttle control motor, on models with an electronic throttle. The system consists of the servo (on some models), brake switch, control switches, a relay and associated wiring. Listed below are some general procedures that may be used to locate common cruise control problems.

2 Locate and check the fuse (see Section 3).

3 Have an assistant operate the brake lights while you check their operation (voltage from the brake light switch deactivates the cruise control).

4 If the brake lights don't come on or don't shut off, correct the problem and retest the cruise control.

5 Inspect the cable linkage between the cruise control servo and the throttle linkage. The cruise control servo is mounted to the RH inner guard.

6 Visually inspect the wires and connections to the cruise control servo and check for damaged throttle cable (where fitted).

7 Test drive the vehicle to determine if the cruise control is now working. If it isn't, take it to a dealer service department or an automotive electrical specialist for further diagnosis and repair.

21 Power door lock system - description and check

1 Power door lock systems are operated by bi-directional solenoids located in the doors. The lock switches have two operating positions: Lock and Unlock. These switches activate a relay which in turn connects voltage to the door lock solenoids. Depending on which way the relay is activated, it reverses polarity, allowing the two sides of the circuit to be used alternately as the feed (positive) and earth side.

2 Always check the circuit protection first (see Section 3).

3 Operate the door lock switches in both directions (Lock and Unlock) with the engine off. Listen for the faint click of the relay operating.

4 If there's no click, check for voltage at the switches. If no voltage is present, check the wiring between the fuse panel and the switches for shorts and opens.

5 If voltage is present but no click is heard, test the switch for continuity. Renew it if there's not continuity in both switch positions.

6 If the switch has continuity but the relay doesn't click, check the wiring between the switch and relay for continuity. Repair the wiring if there's no continuity.

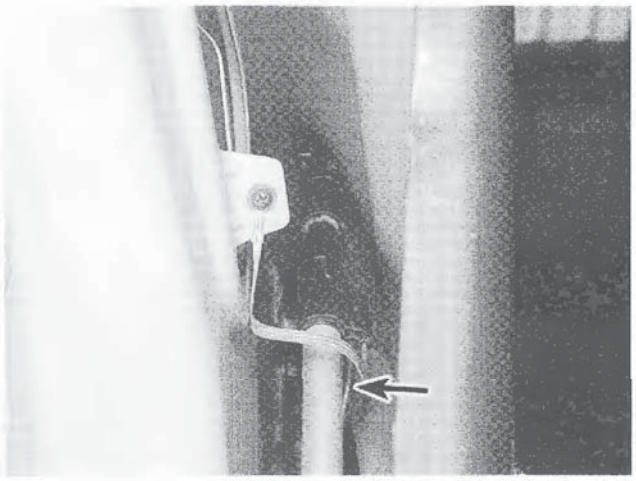
7 If the relay is receiving voltage from the switch but is not sending voltage to the solenoids, check for a bad earth at the relay case. If the relay case is earthing properly, renew the relay.

8 If all but one lock solenoid operates, remove the trim panel from the affected door (see Chapter 11) and check for voltage at the solenoid while the lock switch is operated. One of the wires should have voltage in the Lock position; the other should have voltage in the Unlock position.

9 If the inoperative solenoid is receiving voltage, renew the solenoid.

10 If the inoperative solenoid isn't receiving voltage, check for an open or short in the wire between the lock solenoid and the relay.

> **Note:** *It's common for wires to break in the portion of the harness between the body and door (opening and closing the door fatigues and eventually breaks the wires).*



22.6 The aerial assembly (arrow) is accessible from below

22 Aerial - removal and refitting

Refer to illustration 22.6

1 Disconnect the earth (-) lead from the battery.

> **Caution:** *On models equipped with the Anti-theft audio system, be sure to have the correct radio code before performing any procedure which requires disconnecting the battery (see the front of this manual).*

2 Inside the vehicle, remove the left upper footwell closing panel from the instrument panel (see Chapter 11).

3 Make sure the aerial is fully retracted and disconnect the aerial lead.

4 Remove the left side inner wheel house cover (see Chapter 11).

5 Inside the wheel well, disconnect the aerial wiring harness.

6 Support the aerial, remove the retaining bolt and lower the aerial from the wheel well (see illustration).

7 Refitting is the reverse of removal.

23 Power window system - description and check

1 The power window system consists of the control switches, the motors, glass mechanisms (regulators), and associated wiring.

2 Power windows are wired so they can be lowered and raised from the master control switch by the driver or by remote

switches located at the individual windows. Each window has a separate motor, which is reversible. The position of the control switch determines the polarity and therefore the direction of operation. The system is equipped with a relay that controls current flow to the motors.

3 The power window system operates when the ignition switch is ON. In addition, some models have a window lockout switch at the master control switch which, when activated, disables the switches at the rear windows and, sometimes, the switch at the passenger's window also. Always check these items before troubleshooting a window problem.

4 These procedures are general in nature, so if you can't find the problem using them, take the vehicle to a dealer service department or other qualified repair shop.

5 If the power windows don't work at all, check the fuse or circuit breaker.

6 If only the rear windows are inoperative, or if the windows only operate from the master control switch, check the rear window lockout switch for continuity in the unlocked position. Renew it if it doesn't have continuity.

7 Check the wiring between the switches and fuse panel for continuity. Repair the wiring, if necessary.

8 If only one window is inoperative from the master control switch, try the other control switch at the window.

Note: *This doesn't apply to the driver door window.*

9 If the same window works from one switch, but not the other, check the switch for continuity.

10 If the switch tests OK, check for a short or open in the wiring between the affected switch and the window motor.

11 If one window is inoperative from both switches, remove the trim panel from the affected door and check for voltage at the motor while the switch is operated.

12 If voltage is reaching the motor, disconnect the glass from the regulator (see Chapter 11). Move the window up and down by hand while checking for binding and damage. Also check for binding and damage to the regulator. If the regulator is not damaged and the window moves up and down smoothly, renew the motor (see Chapter 11). If there's binding or damage, lubricate, repair or renew parts, as necessary.

13 If voltage isn't reaching the motor, check the wiring in the circuit for continuity between the switches and motors. Check that the relay is earthed properly and receiving voltage from the switches. Also check that the relay sends voltage to the motor when the switch is turned on. If it doesn't, renew the relay.

14 Test the windows after you are done to confirm proper repairs.

24 Electric rear view mirrors - description and check

1 Electric rear view mirrors use two motors to move the glass; one for up-and-down adjustments and one for left-to-right adjustments.

2 The control switch has a selector portion which sends voltage to the left or right side mirror. With the ignition ON but the engine OFF, roll down the windows and operate the mirror control switch through all functions (left-right and up-down) for both the left and right side mirrors.

3 Listen carefully for the sound of the electric motors running in the mirrors.

4 If the motors can be heard but the mirror glass doesn't move, there's probably a problem with the drive mechanism inside the mirror. Remove and disassemble the mirror to locate the problem.

5 If the mirrors don't operate and no sound comes from the mirrors, check the fuse (see Section 3).

6 If the fuse is OK, remove the mirror control switch from its mounting without disconnecting the wires attached to it. Turn the ignition ON and check for voltage at the switch. There should be voltage at one terminal. If there's no voltage at the switch, check for an open or short in the wiring between the fuse panel and the switch.

7 If there's voltage at the switch, disconnect it. Check the switch for continuity in all its operating positions. If the switch does not have continuity, renew it.

8 Re-connect the switch. Locate the wire going from the switch to earth. Leaving the switch connected, connect a jumper wire between this wire and earth. If the mirror works normally with this wire in place, repair the faulty earth connection.

9 If the mirror still doesn't work, remove the cover and check the wires at the mirror for voltage with a test light. Check with ignition ON and the mirror selector switch on the appropriate side. Operate the mirror switch in all its positions. There should be voltage at one of the switch-to-mirror wires in each switch position (except the neutral "off" position).

10 If there's not voltage in each switch position, check the wiring between the mirror and control switch for opens and shorts.

11 If there's voltage, remove the mirror and test it off the vehicle with jumper wires. Renew the mirror if it fails this test (see Chapter 11).

25 Airbags (Supplemental Restraint System [SRS]) - general information

Warning: *These models are equipped with airbags (Supplemental Restraint System [SRS]). The models are identified by the wording "SRS AIRBAG" on the steering wheel horn pad and instrument panel above the glovebox and the passenger's door (if equipped with a passenger's airbag). The airbag could accidentally deploy, causing serious injury and damage if any of the system wiring or components are disturbed. These components are located under the driver's seat, at the steering wheel, steering column and behind the dash. The yellow-covered wires connecting these locations must not be tampered with. Do not use test equipment on these wires. Refer to Section 26 for disabling and enabling procedures.*

1 These models are equipped with the SRS airbag system. This is a "passive" restraint system because the driver has no control over its occupant(s). It is designed to protect the driver from serious injury in the event of a frontal impact.

2 Some systems have a driver's-side-only system. Others have another airbag for the other front seat occupant. You can tell if your vehicle has either of these by checking the steering wheel horn pad and the instrument panel above the glove box for the wording "SRS AIR BAG".

3 The driver's side device is in the steering wheel hub. The passenger's is in the dash. The "brain" is a sensing diagnostic module under the driver's seat. An AIR BAG warning lamp is located in the instrument panel. All of the wiring connecting the various components is covered with yellow conduit with the SRS label.

4 The sensing diagnostic module contains a microprocessor which monitors the operation of the system. It also performs a check of the system every time the car is started. If it is working properly, the AIR BAG lamp will operate for two seconds after starting and then stop. If there is a fault, the lamp will stay on and it will store trouble codes indicating the nature of the problem. A special scan tool (normally only found at Holden dealers) is required to retrieve these codes.

Warning: *If the AIR BAG warning lamp comes on during driving or stays on after starting, the car must be taken to a dealer for service at once.*

5 Do not attempt to diagnose or troubleshoot the SRS system on your own. This system is designed to save lives. Any tampering with it could destroy its effectiveness.

6 Always temporarily disable the SRS system when working anywhere near the system components or wiring.

26 Airbags (SRS system) - disabling and enabling

DISABLING THE SYSTEM

1 Point the steering wheel to the straight ahead position. The front wheels must be pointing straight.

2 Turn the key to LOCK and remove it.

3 Disconnect the battery earth lead followed by the power lead.

4 Wait at least 10 seconds for voltage to run out of the system.

ENABLING THE SYSTEM

5 Reconnect the battery power lead followed by the earth lead.

6 Switch the ignition On and ensure the SRS warning lamp in the instrument cluster stays illuminated for approximately 5 seconds and then goes out. If the warning lamp stays illuminated or an audible chime can be heard, there is a fault in the system which should be diagnosed by a Holden dealer as soon as possible.

27 Wiring diagrams - general information

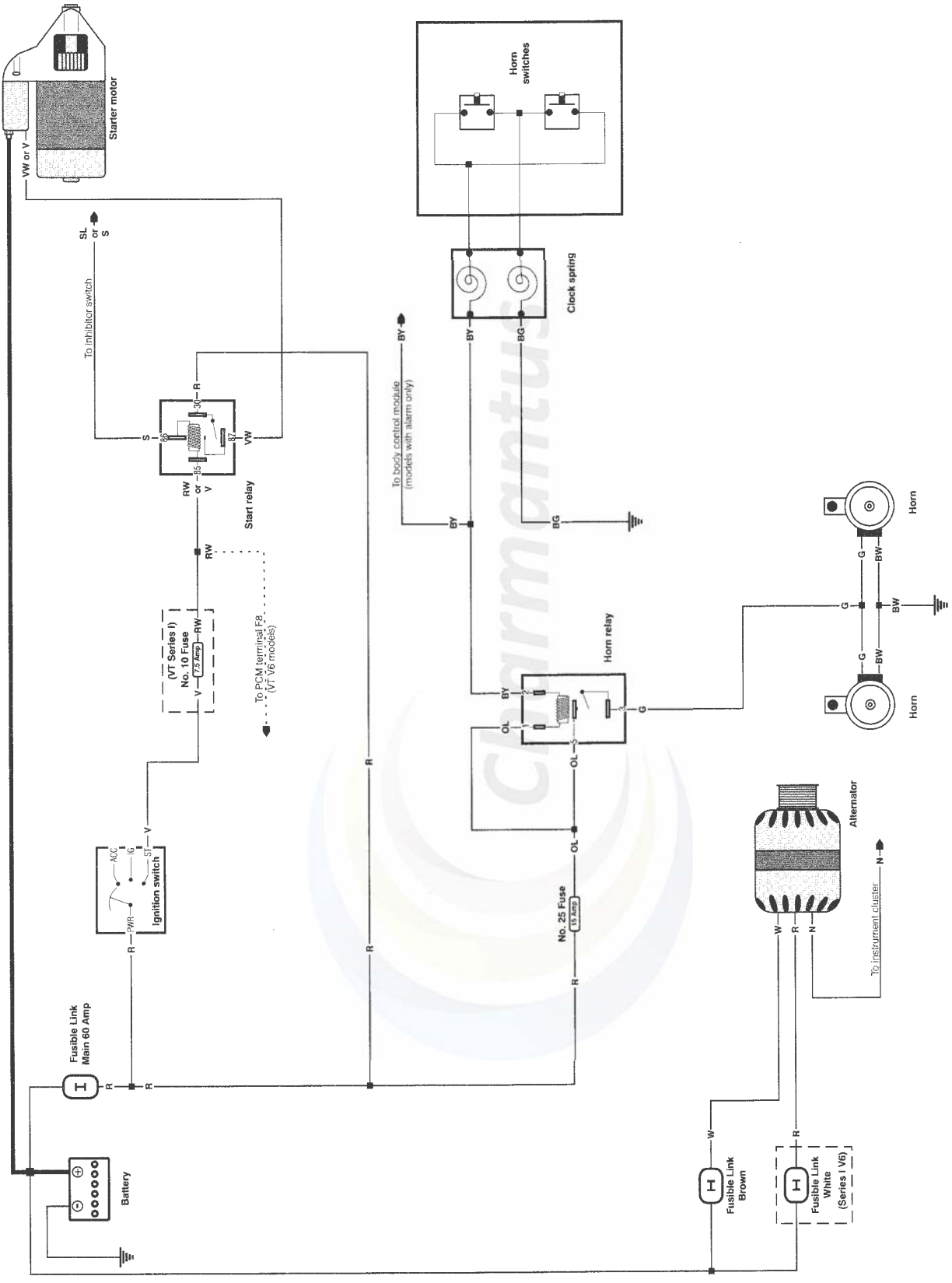
Since it isn't possible to include all wiring diagrams for every year covered by this manual, the following diagrams are those that are typical and most commonly needed.

Prior to troubleshooting any circuit, check the fuse and circuit breakers (if equipped) to make sure they're in good condition. Make sure the battery is properly charged and check the cable connections (see Chapter 1).

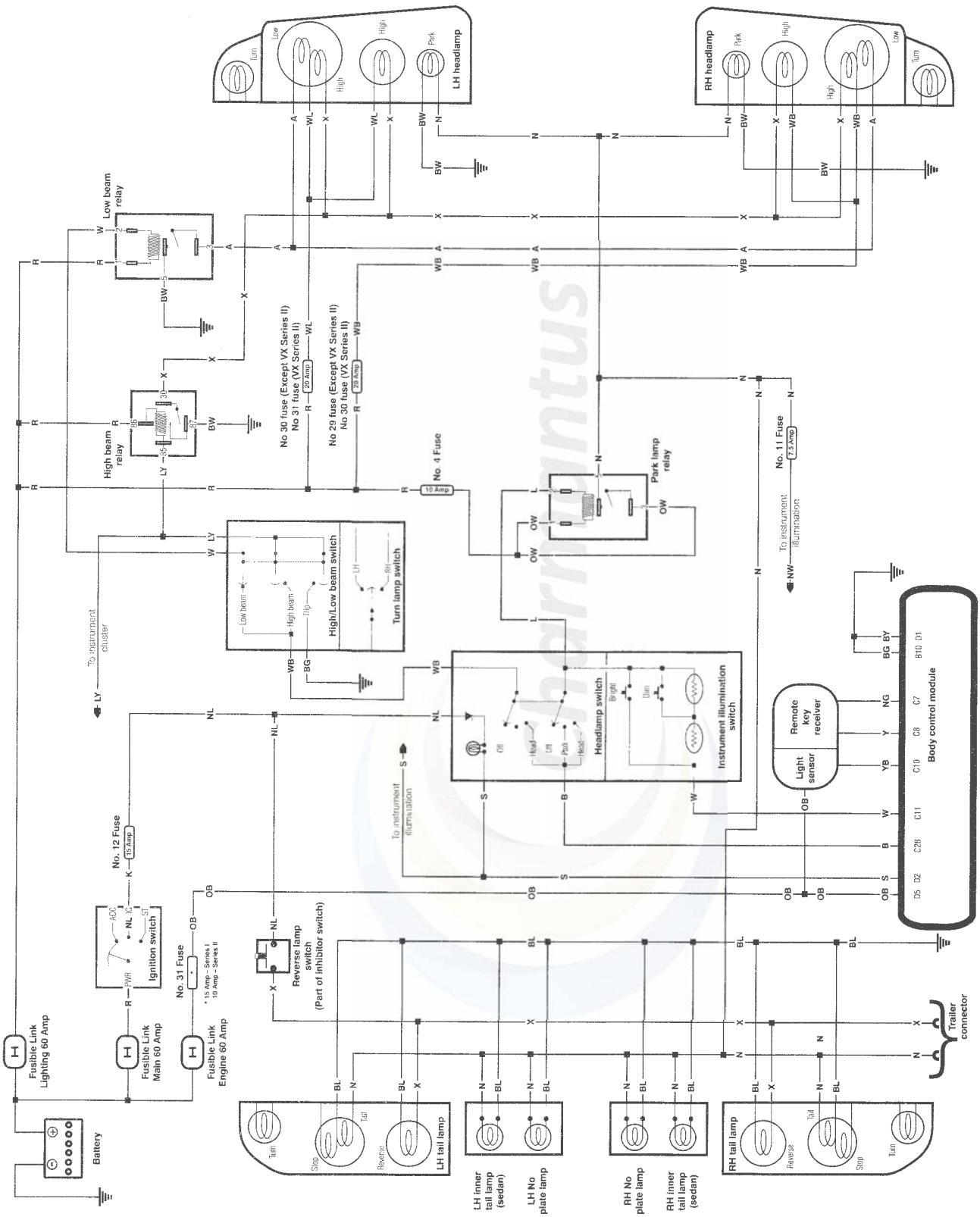
When checking a circuit, make sure that all electrical connectors are clean, with no broken or loose terminals. When unplugging an electrical connector, do not pull on the wires. Pull only on the connector housings themselves.

Colour Code		
A – Tan	**N** – Brown	**V** – Violet
B – Black	**O** – Orange	**W** – White
G – Green	**P** – Purple	**Y** – Yellow
K – Pink	**R** – Red	**X** – Light green
L – Blue	**S** – Grey	**Z** – Light blue

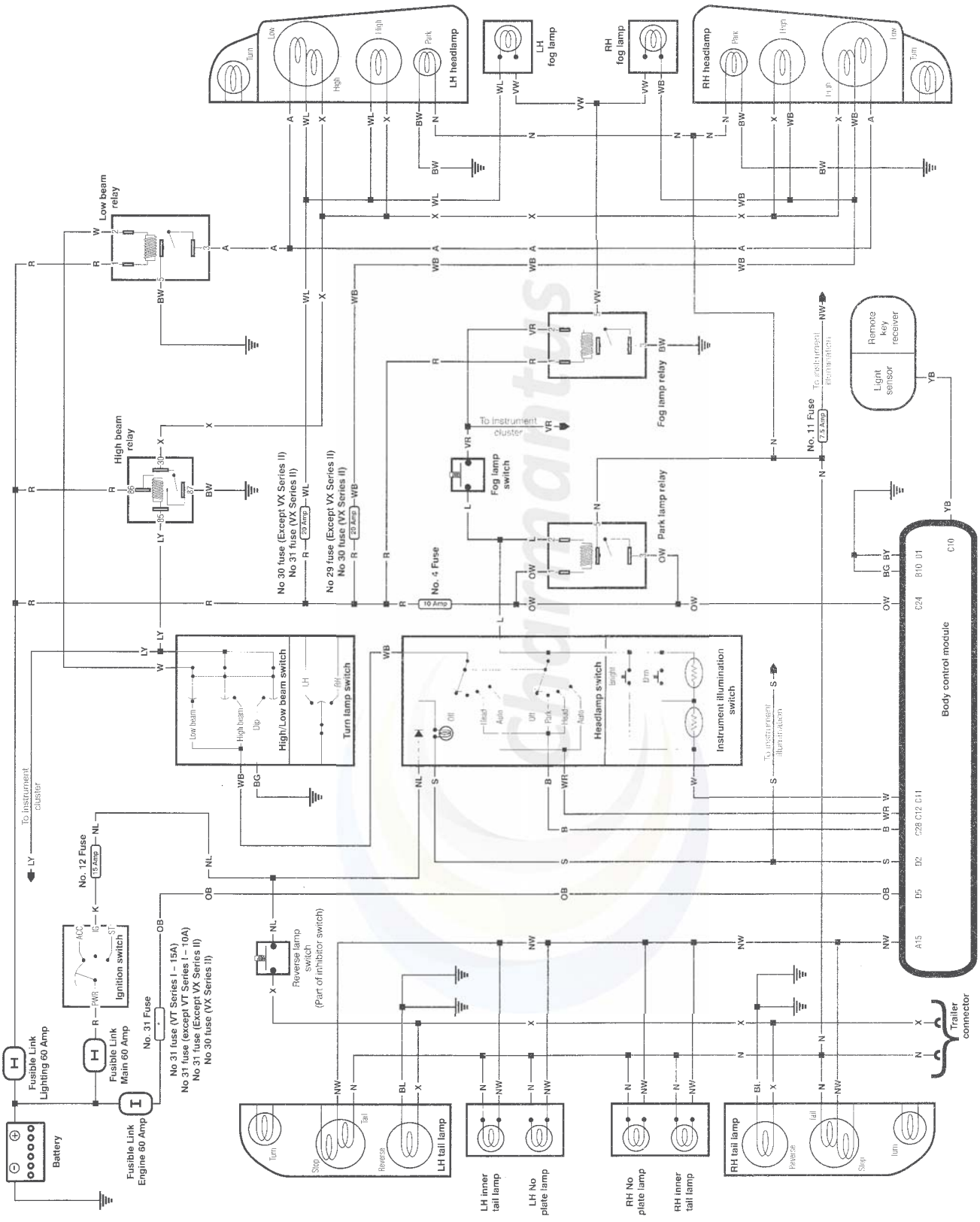
Wiring diagram colour codes



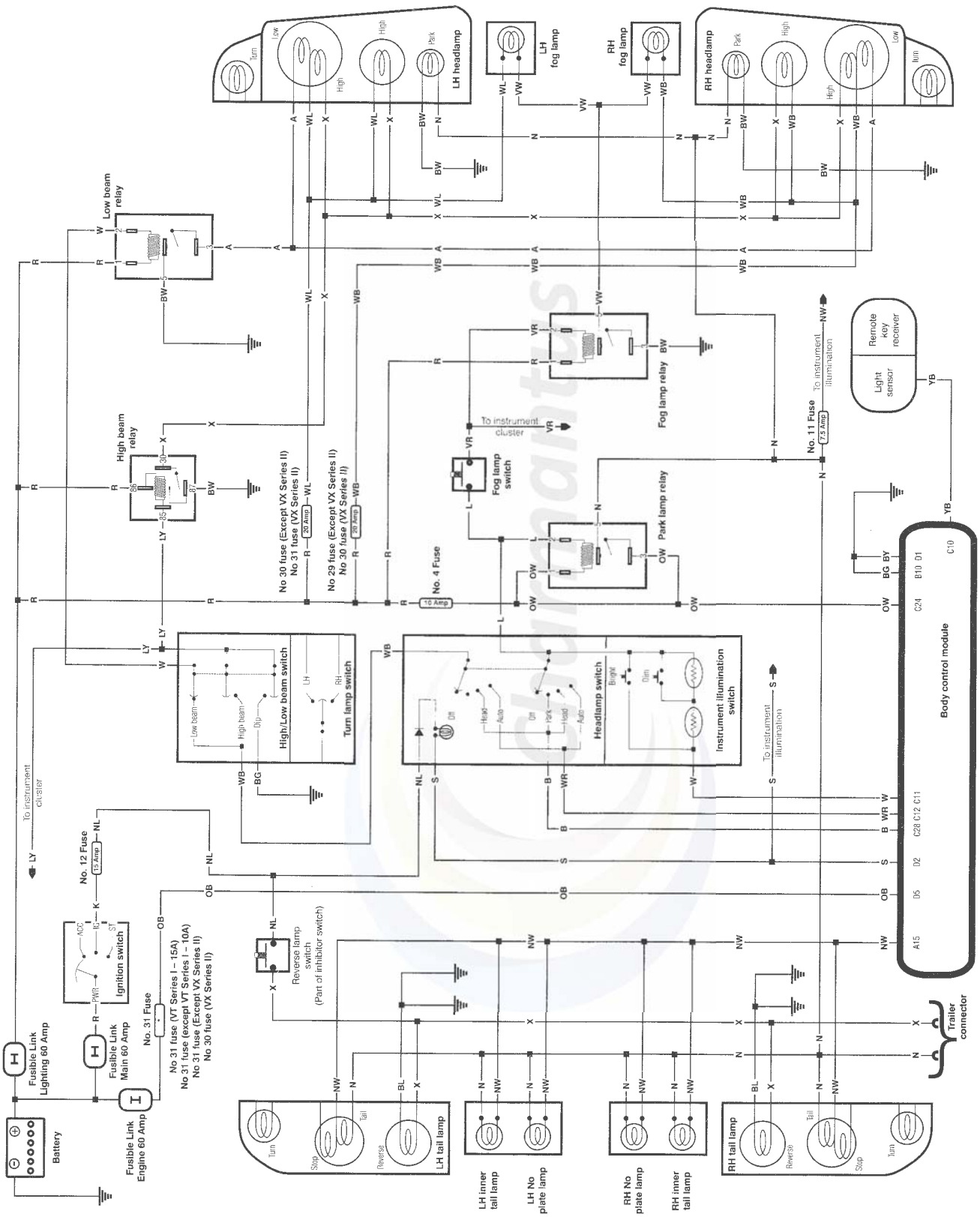
Starting and charging circuits, horn. VT and VX models



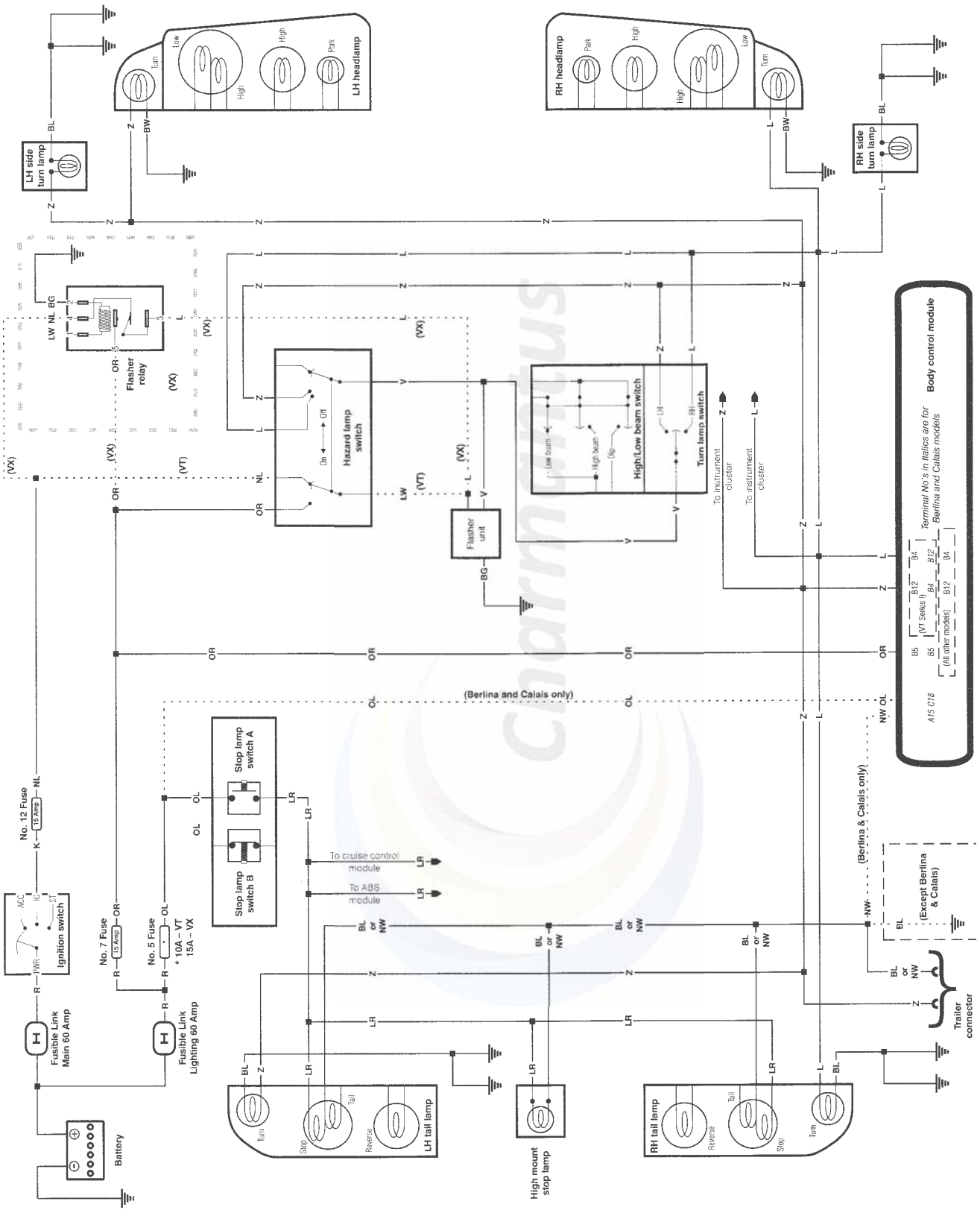
Headlamps, park lamps, reverse lamps, fog lamp circuits. VT and VX Executive models



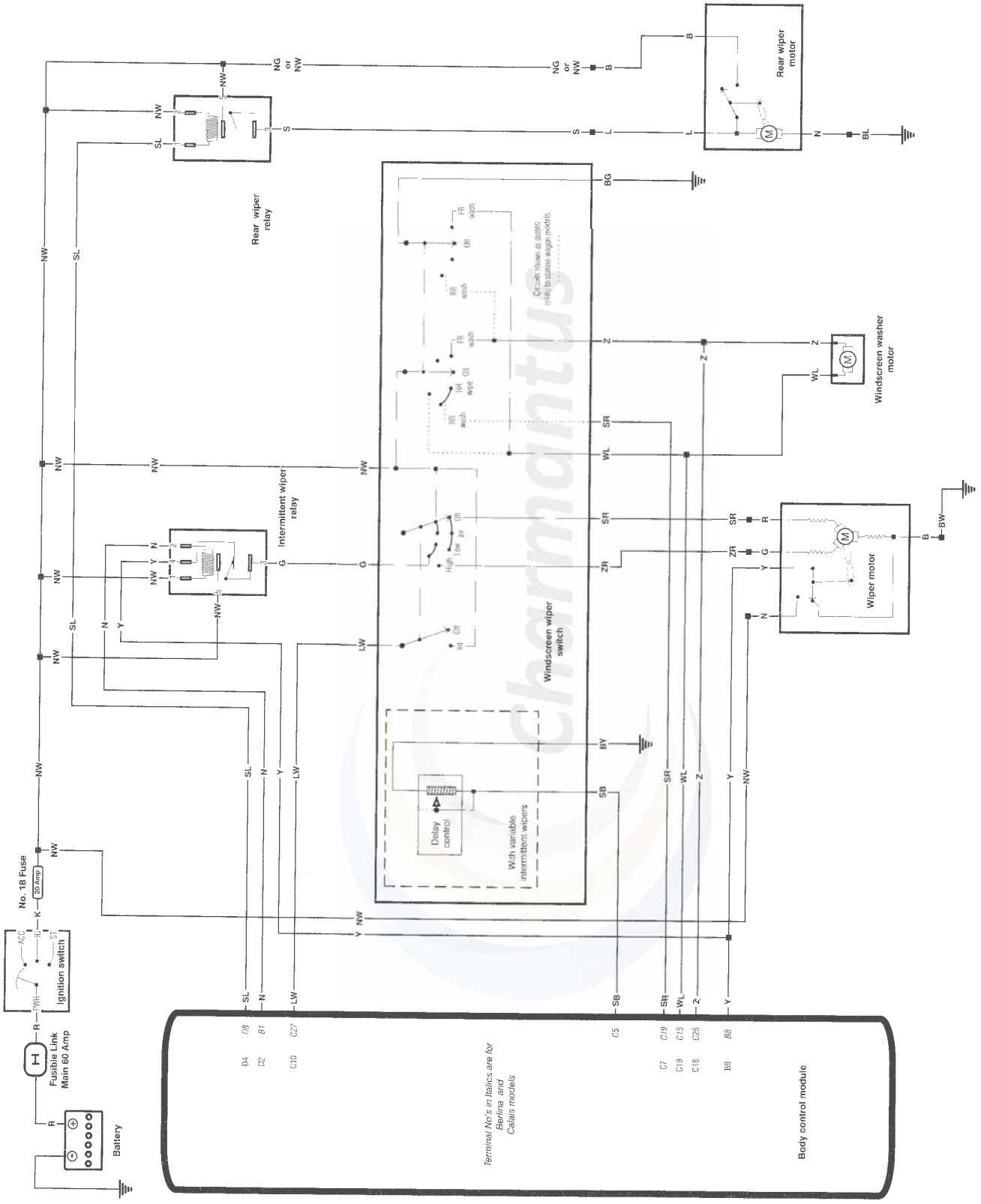
Headlamps, park lamps, reverse lamps, fog lamp circuits. VT and VX Berlina models



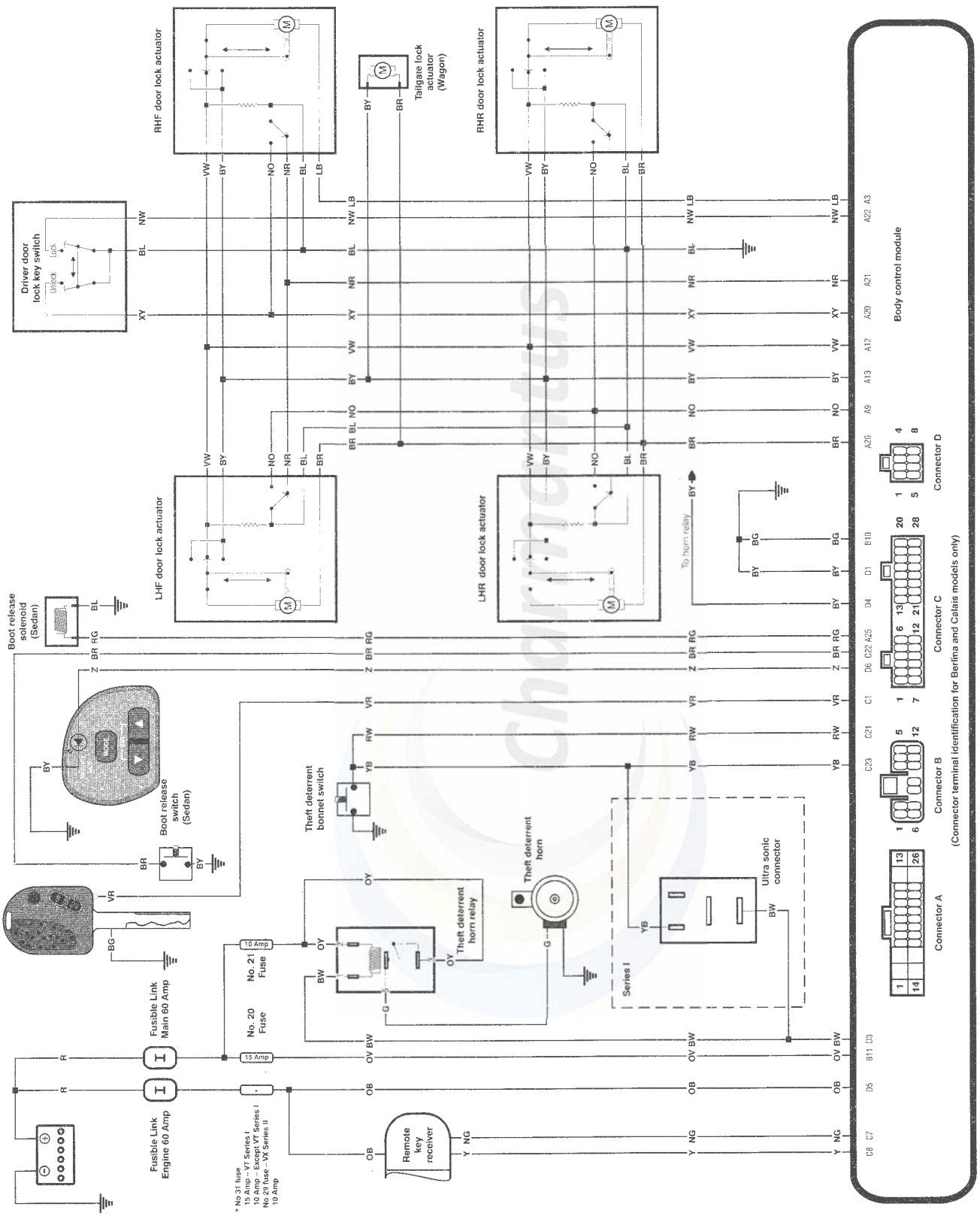
Headlamps, park lamps, reverse lamps, fog lamp circuits. VT and VX Calais models



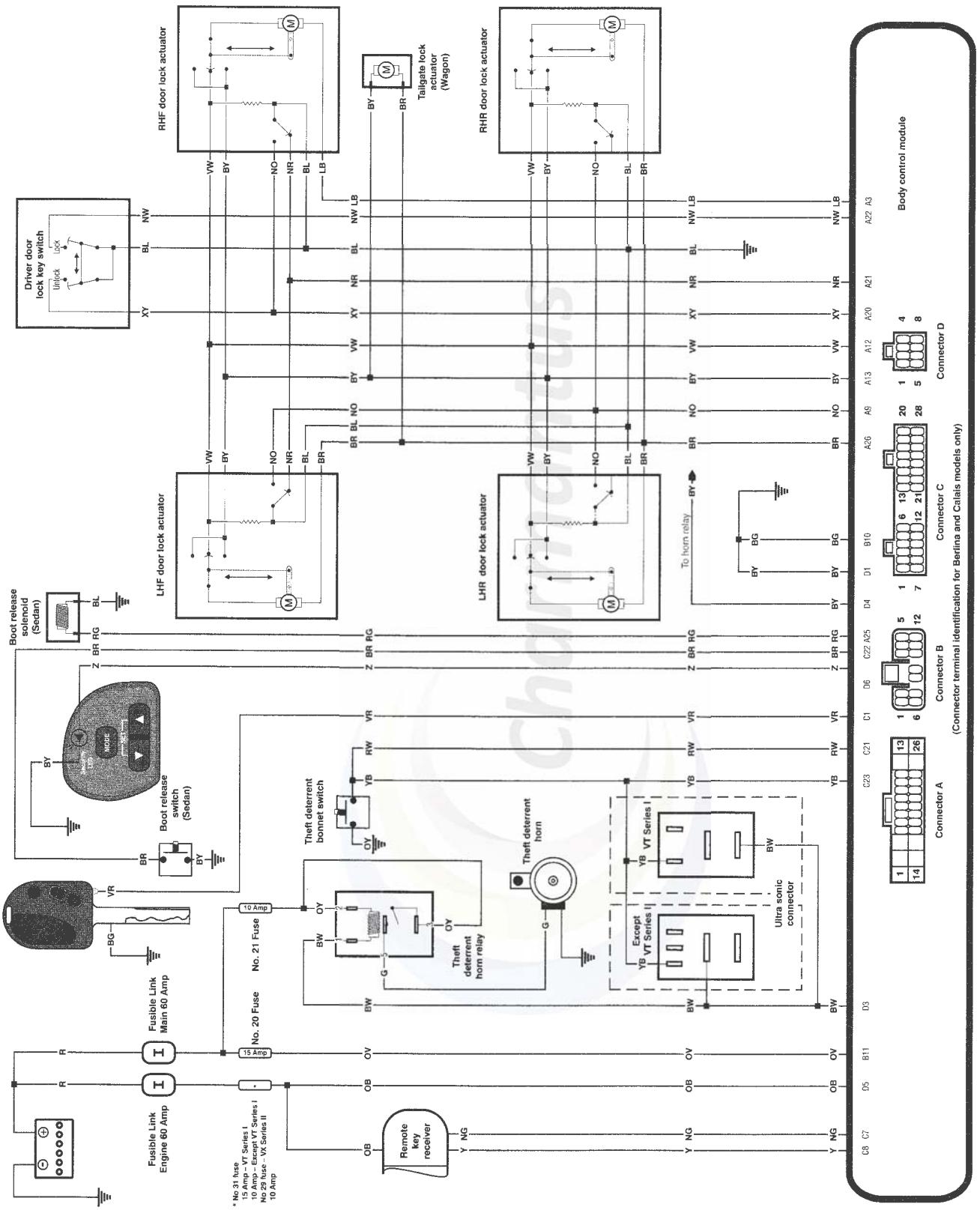
Stop lamps, turn signal circuits. VT and VX models



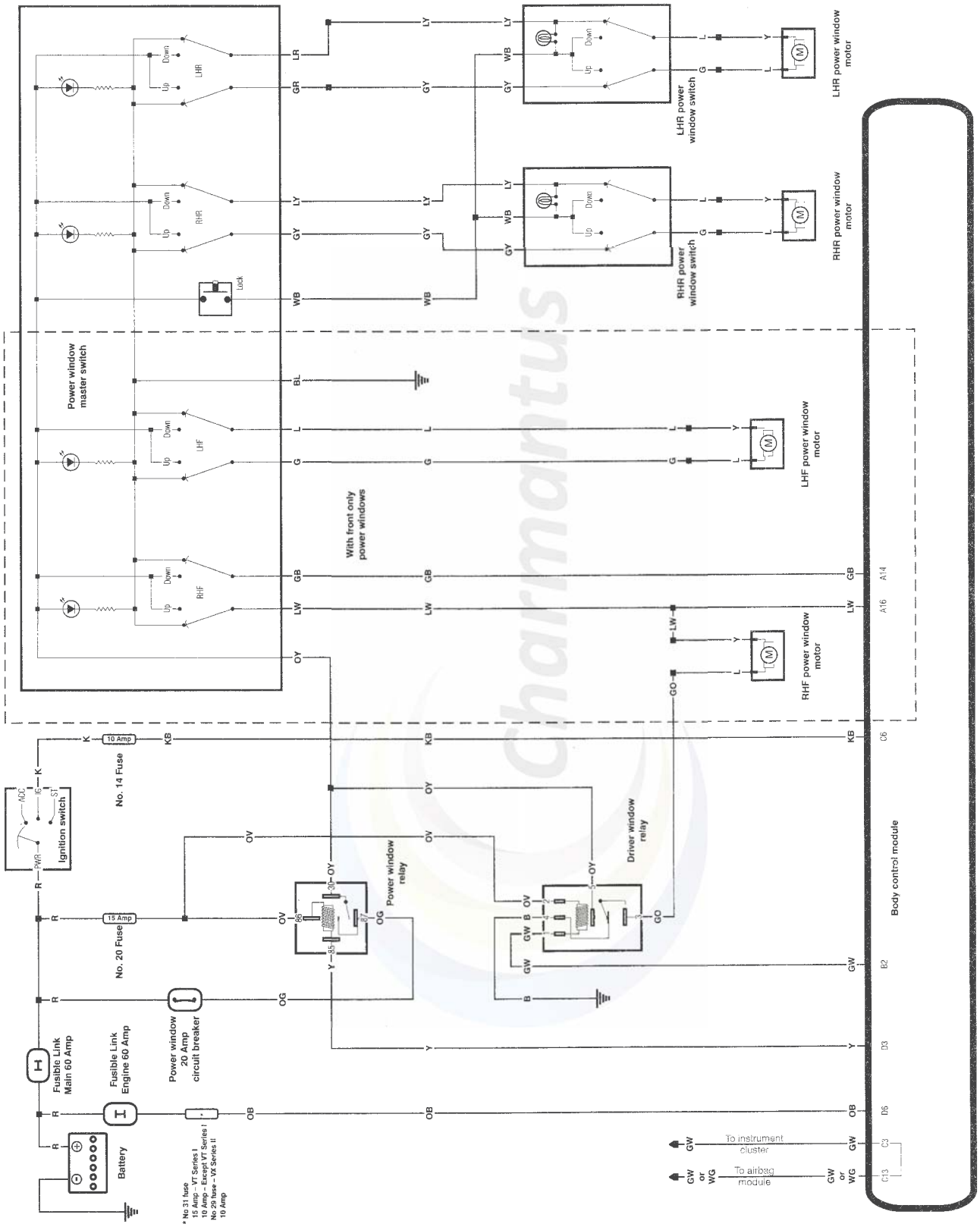
Windscreen wiper and washers. VT and VX models



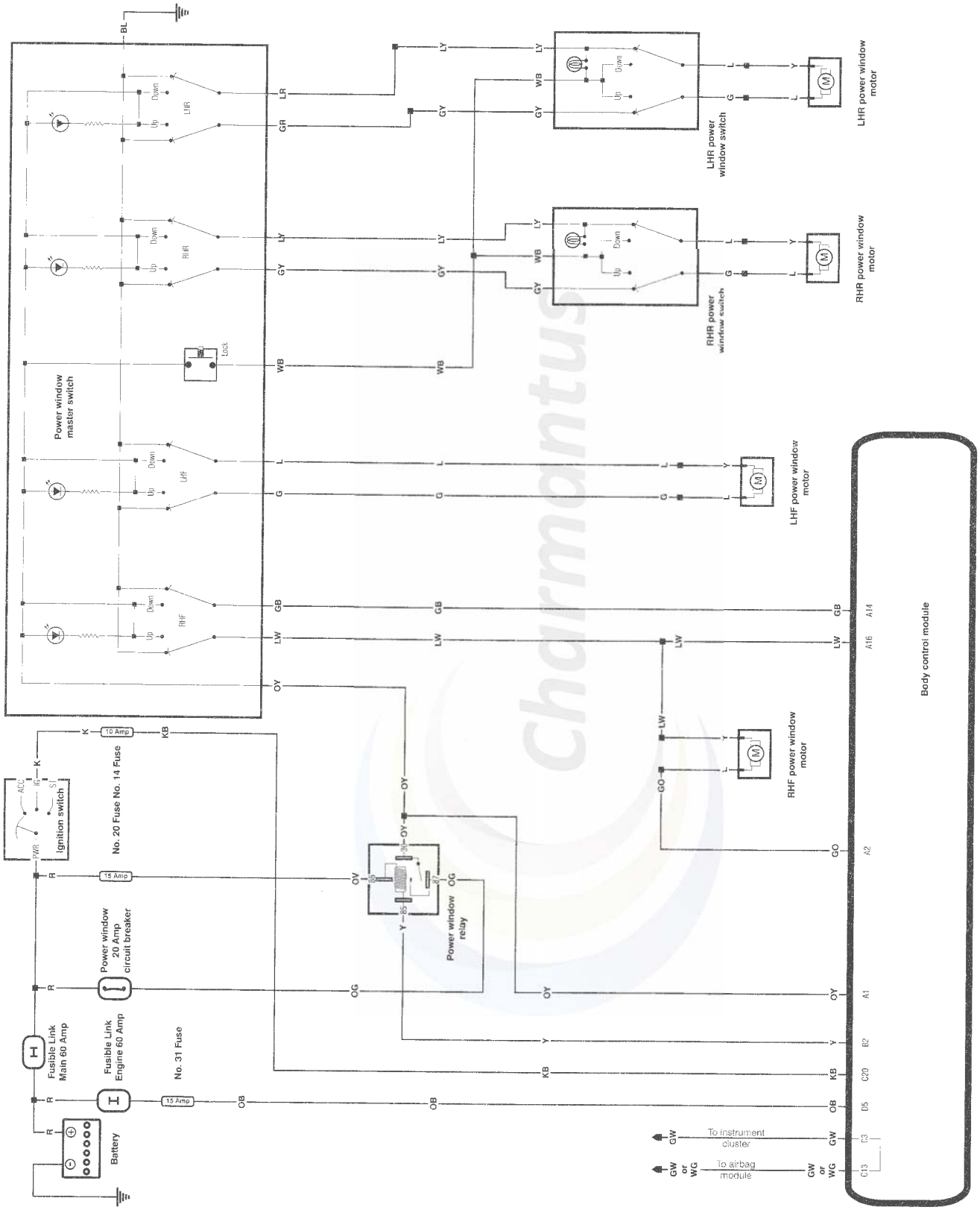
Power door locks, theft detterent system. VT and VX Executive and Berlina models



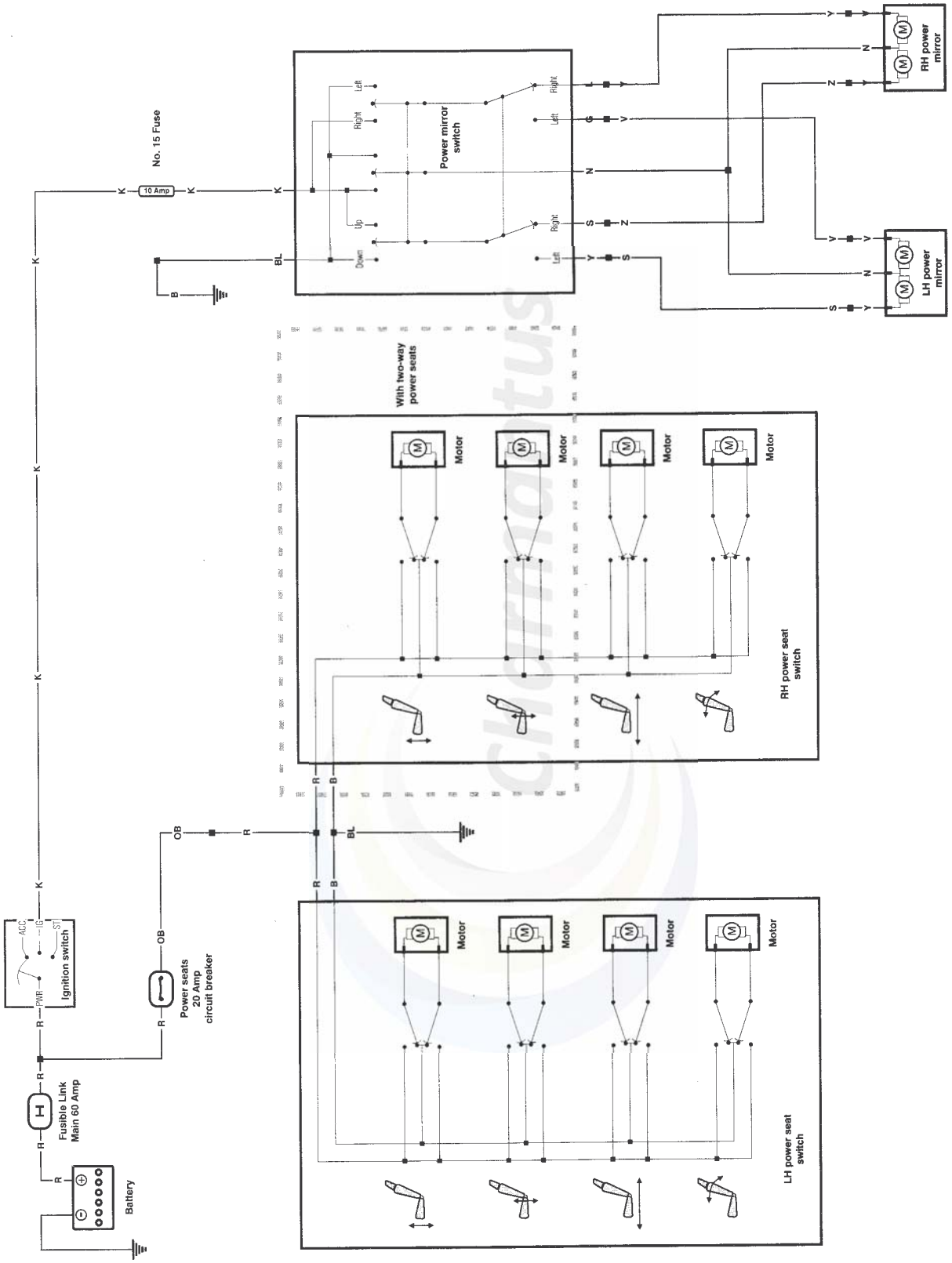
Power door locks, theft detterent system. VT and VX Calais models



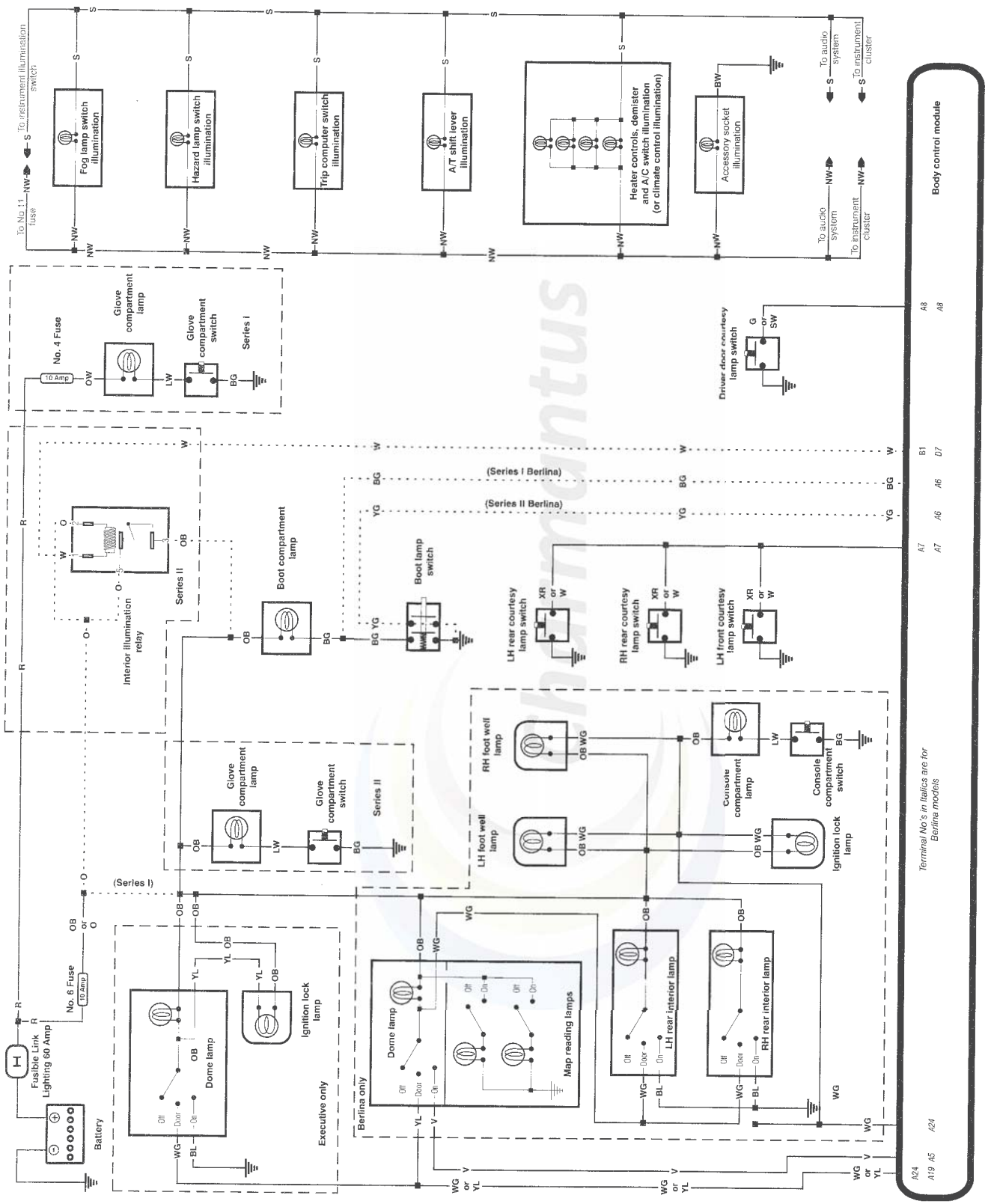
Power windows. VT and VX Executive models



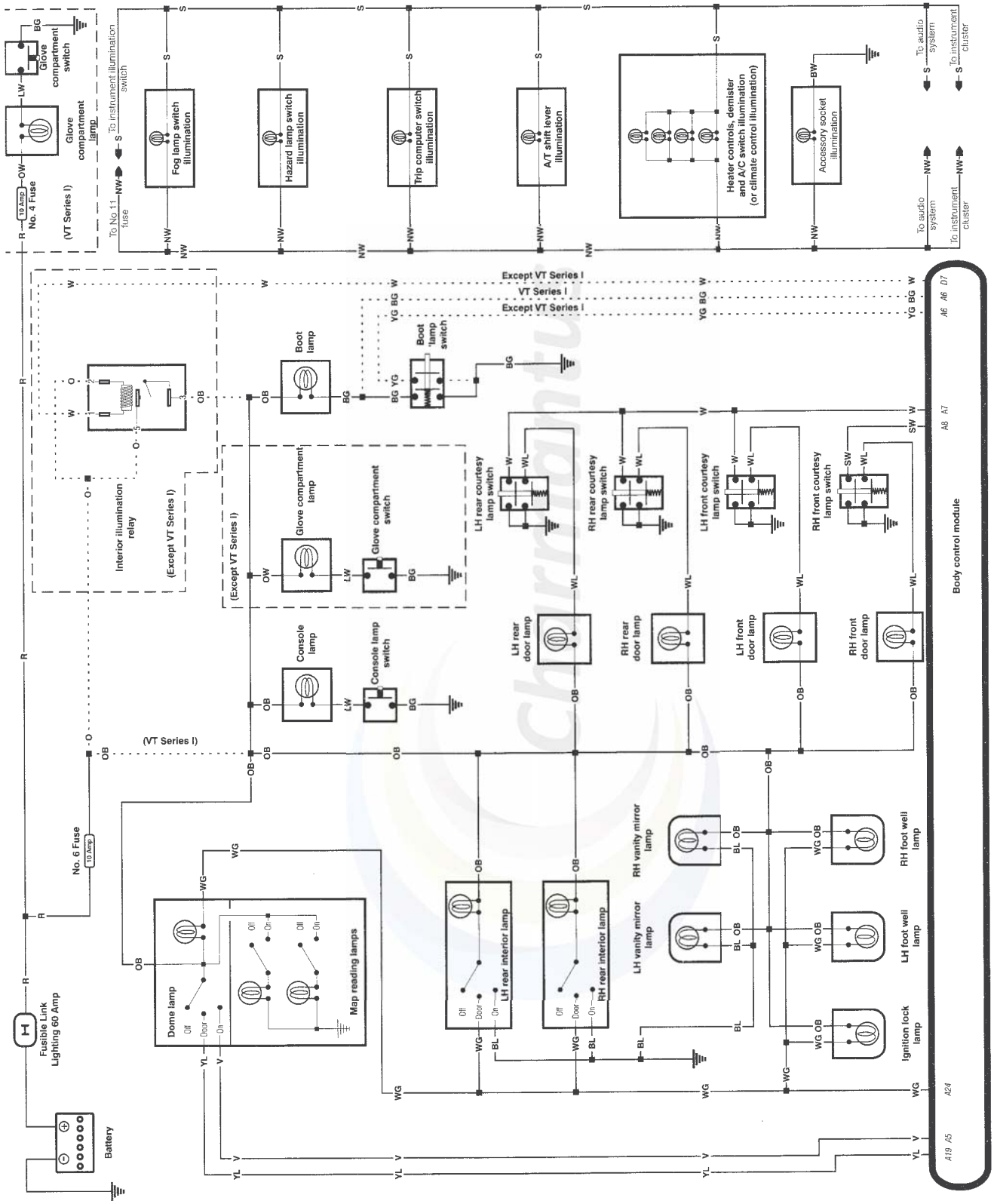
Power windows. VT and VX Berlina and Calais models



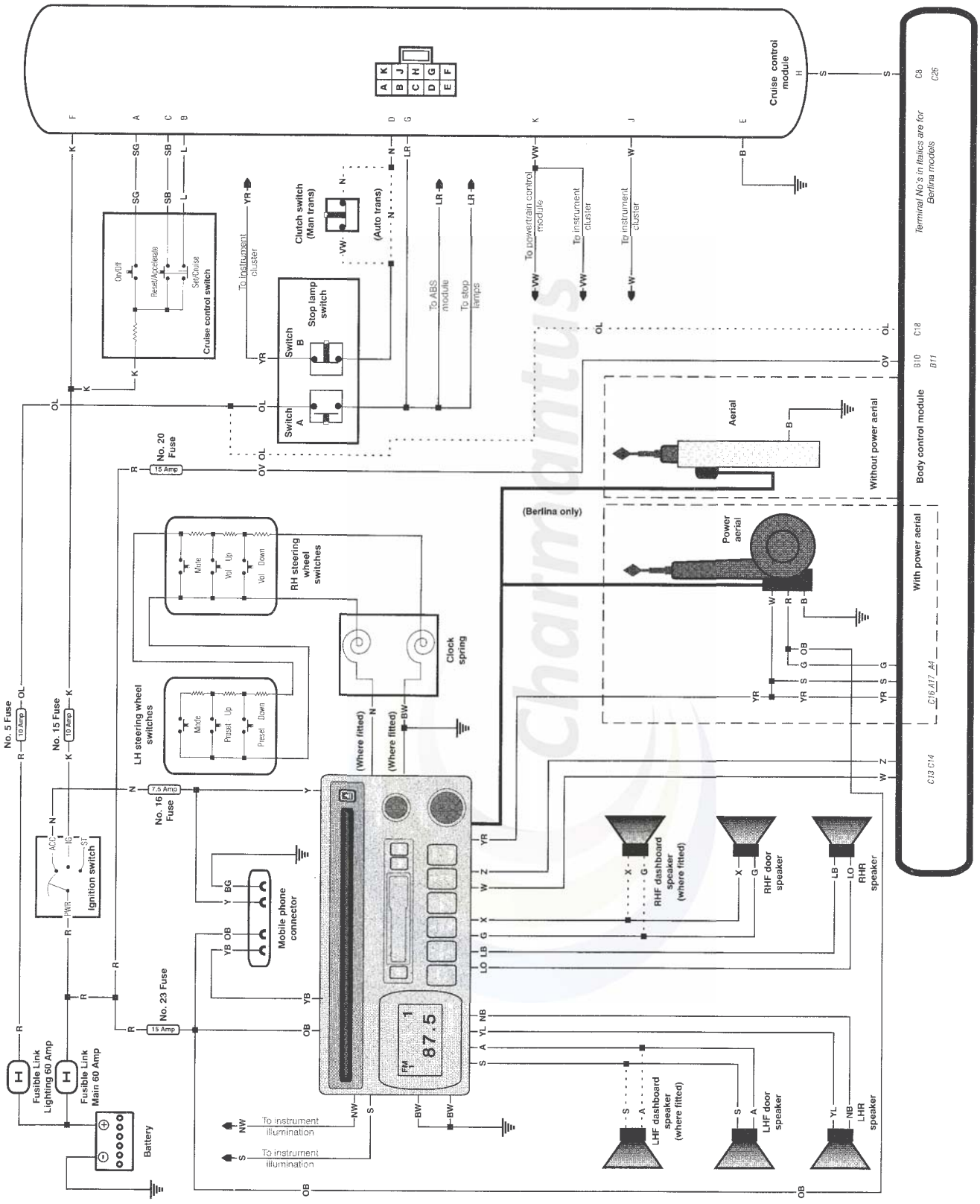
Power seats, power mirrors. VT and VX Berlina and Calais models



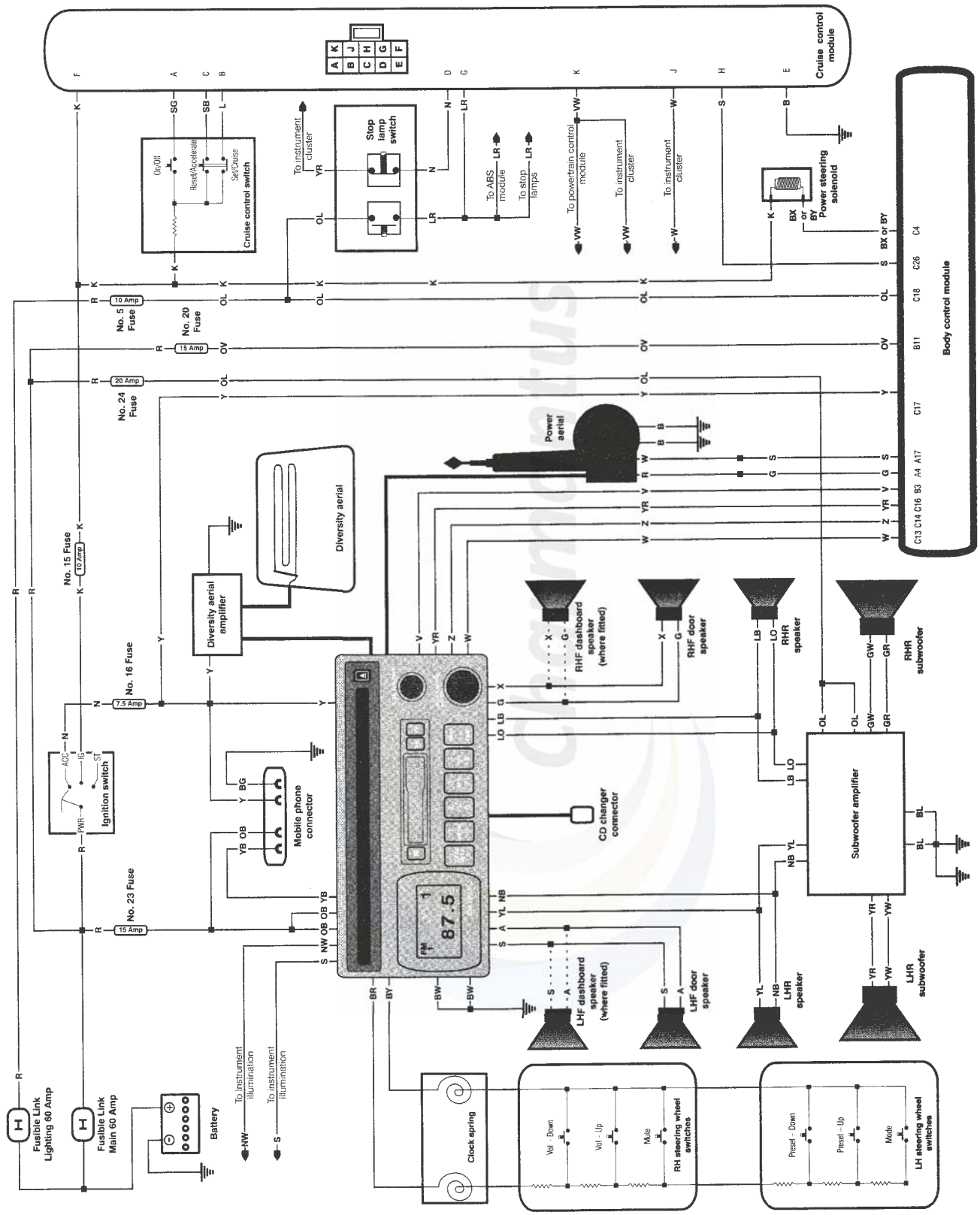
Interior lighting and instrument lighting. VT and VX Executive and Berlina models



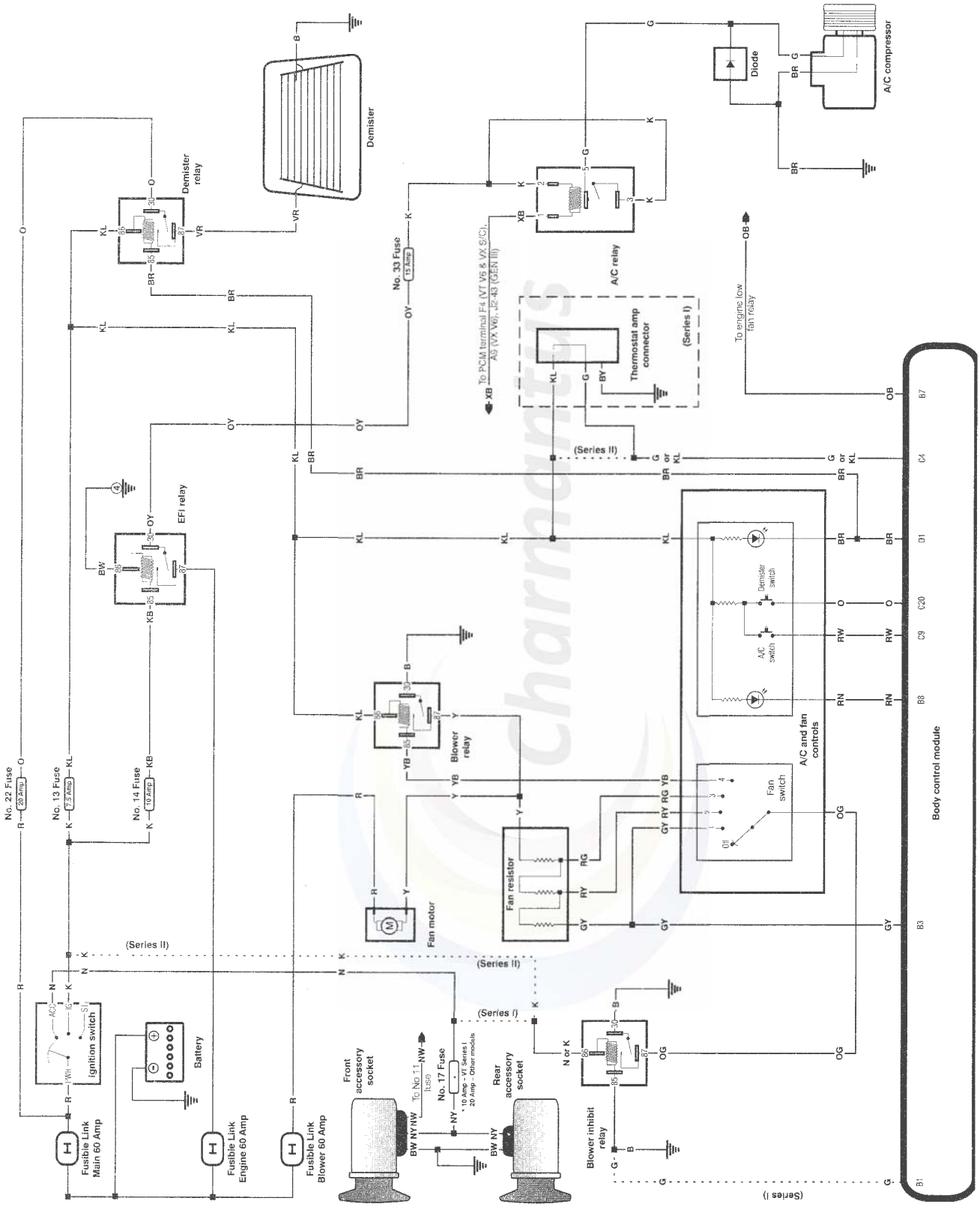
Interior lighting and instrument lighting. VT and VX Calais models



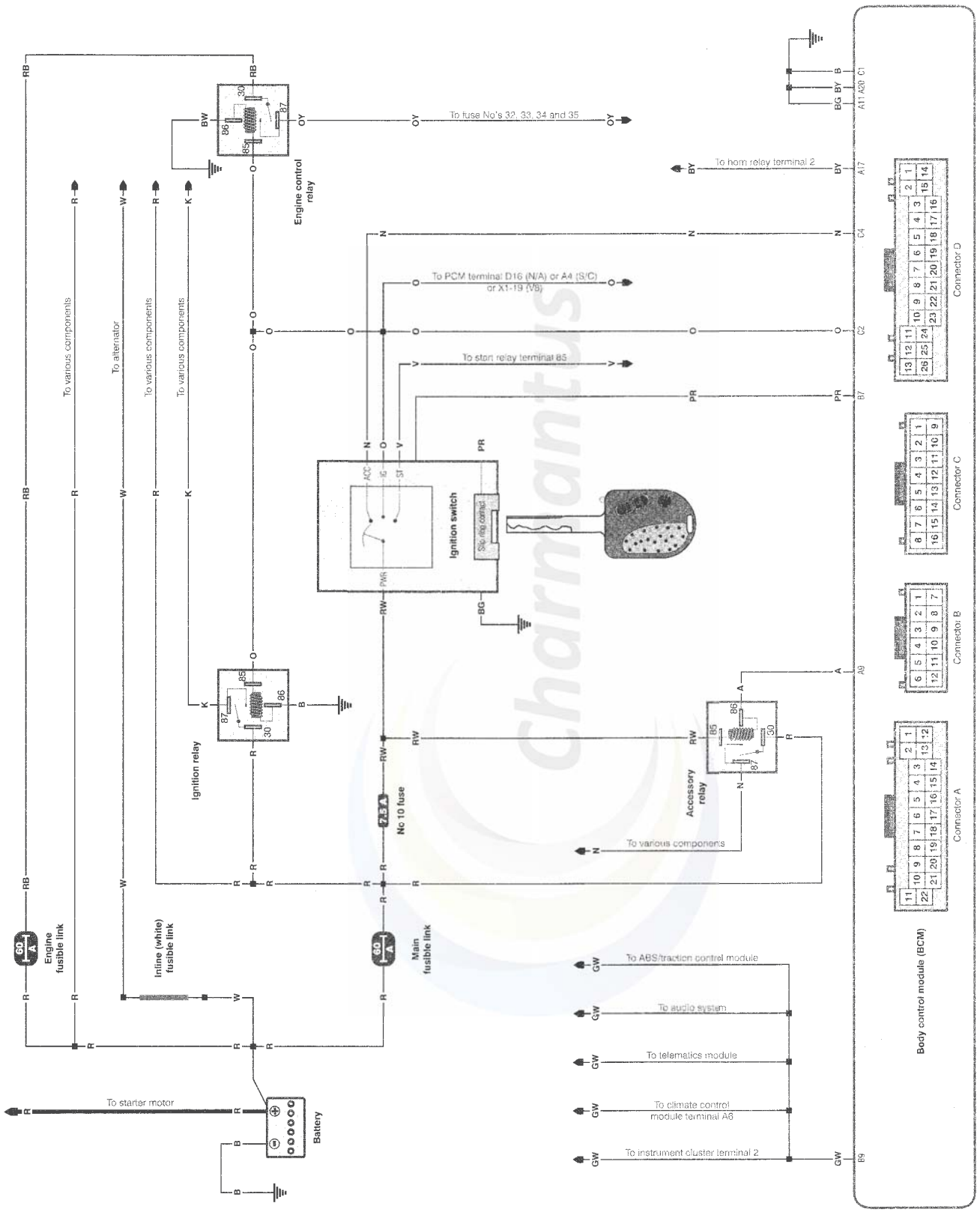
Audio system, cruise control. VT and VX Executive and Berlina models



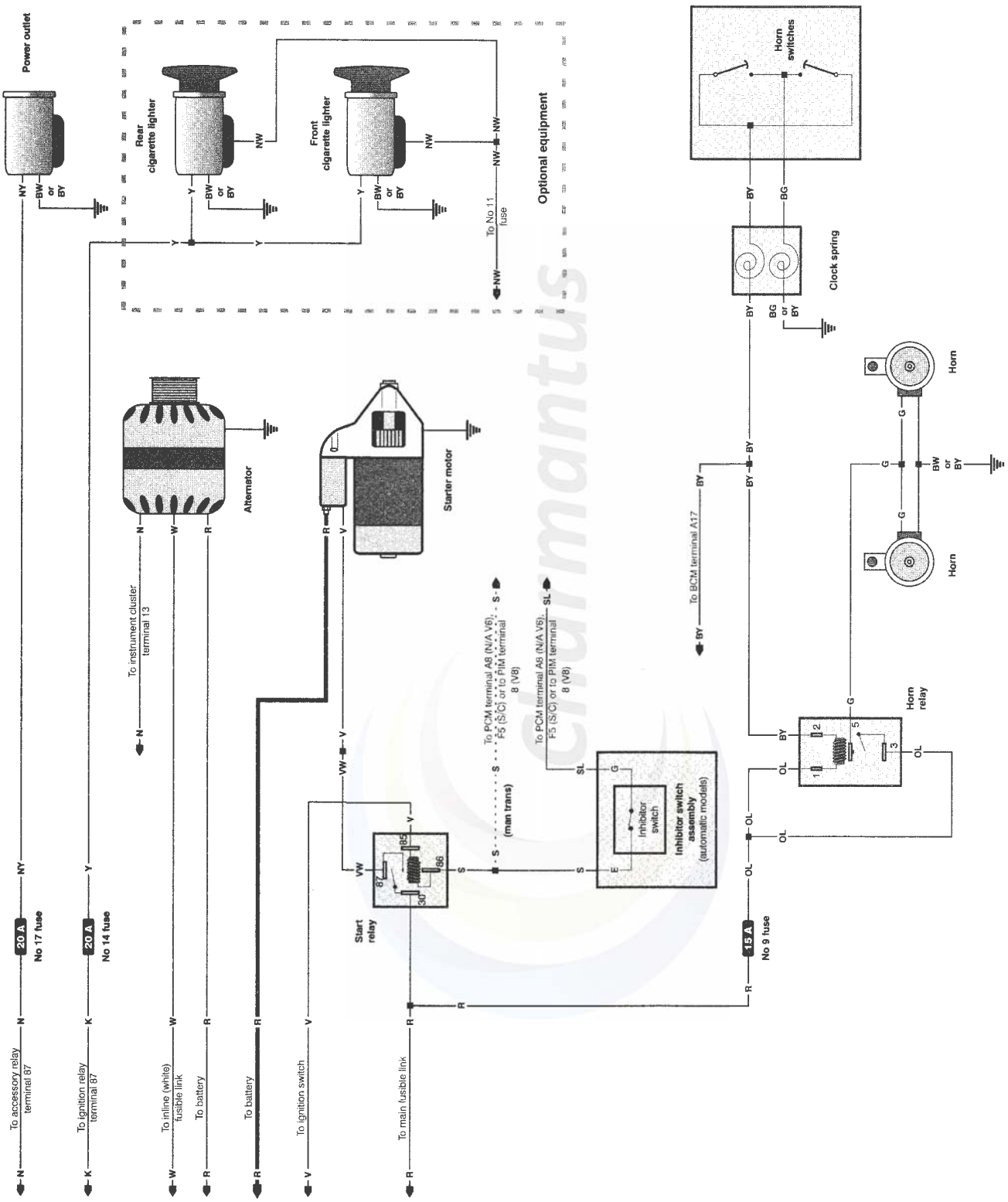
Audio system, cruise control. VT and VX Calais models



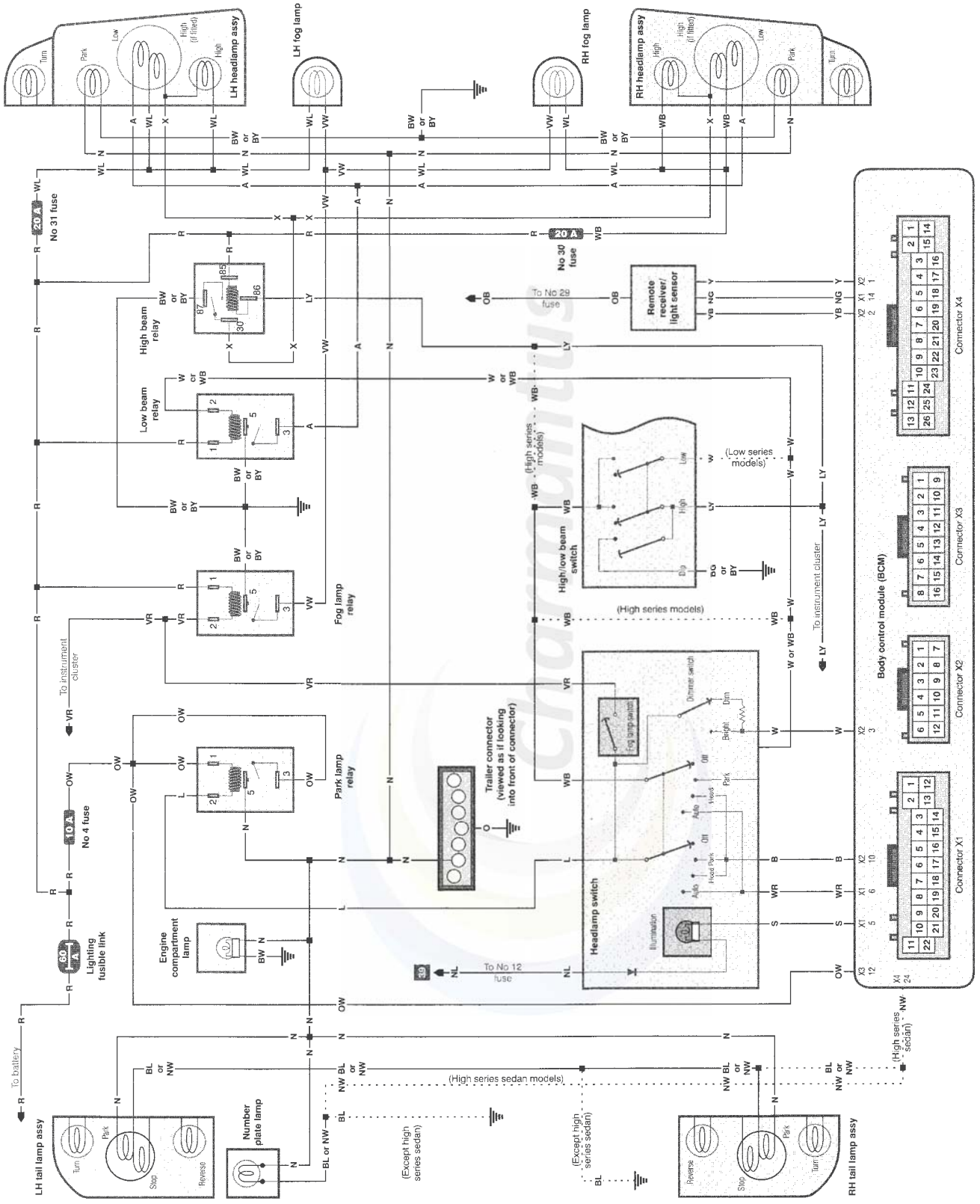
A/C, demister, power outlets. VT and VX models



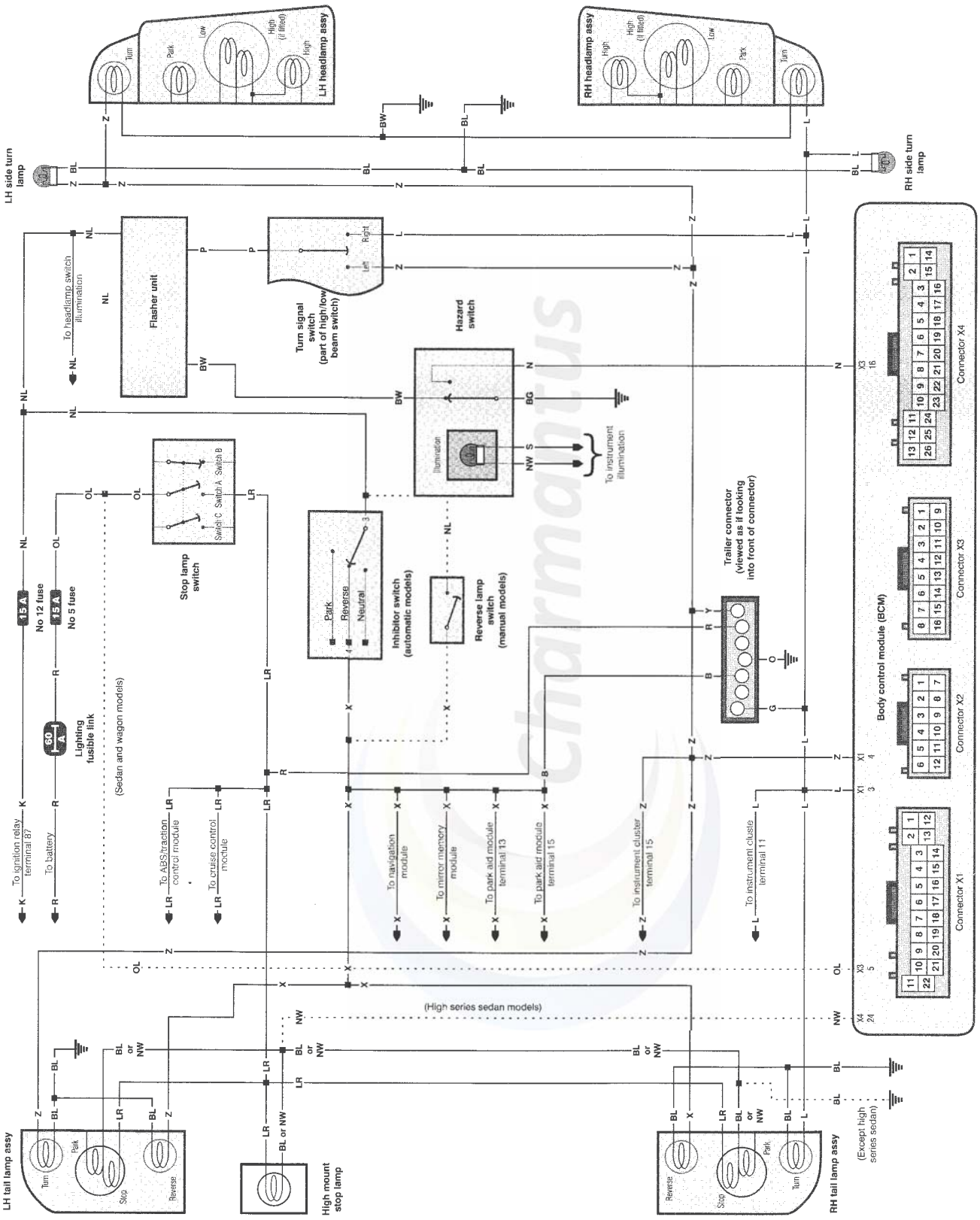
Power distribution. VY models



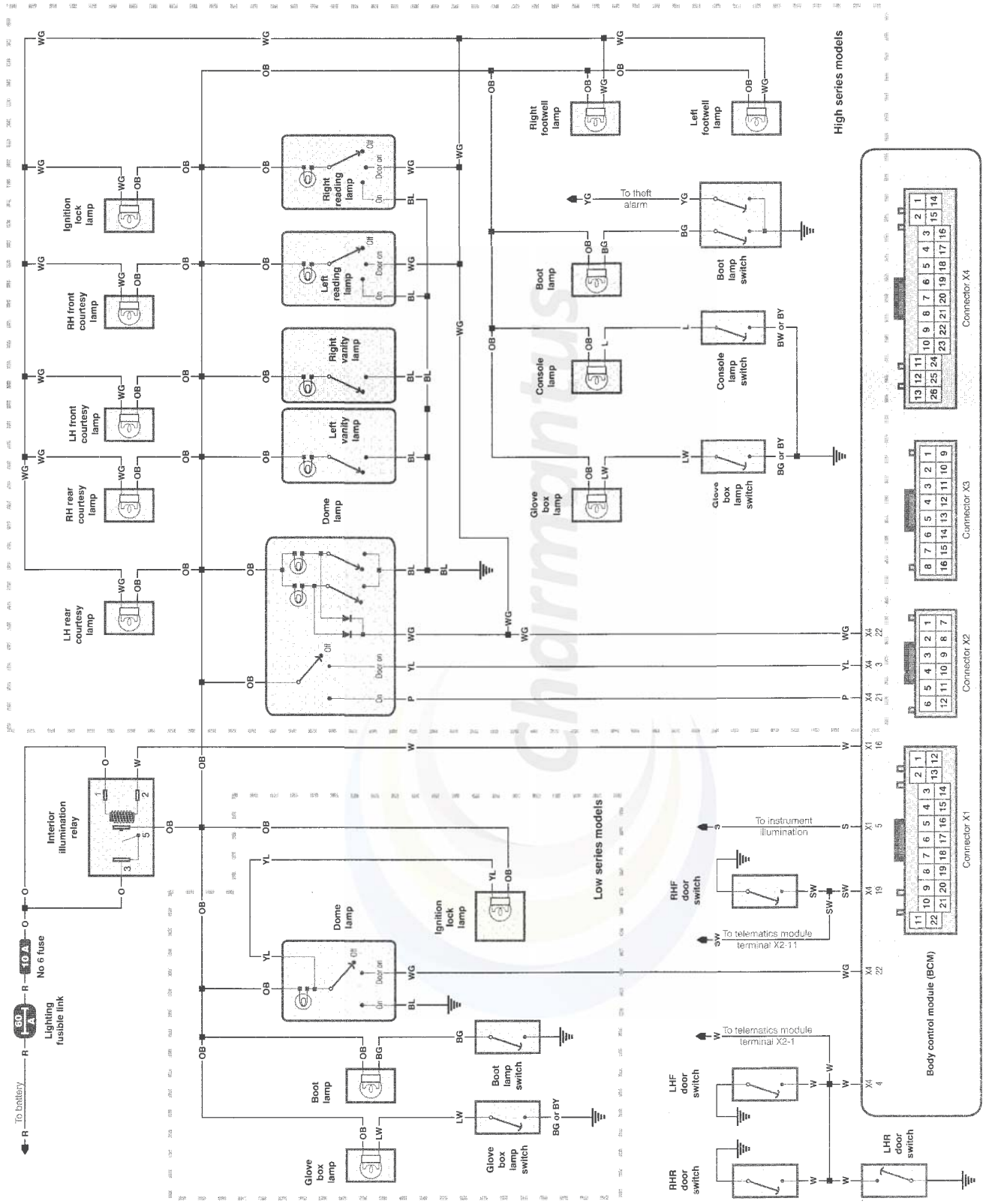
Starting and charging circuits, horn. VY models



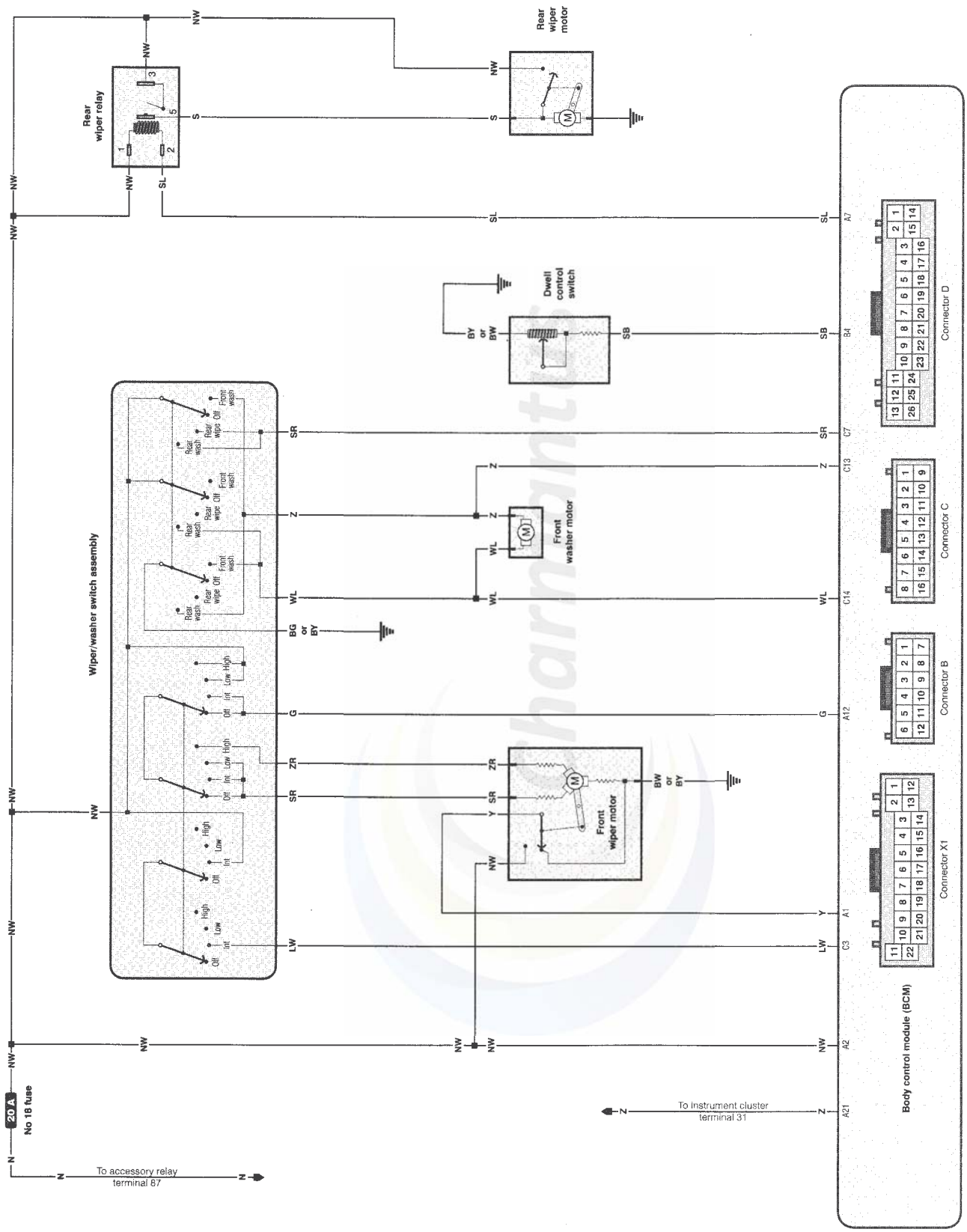
Headlamps, park lamps, fog lamp circuits. VY models



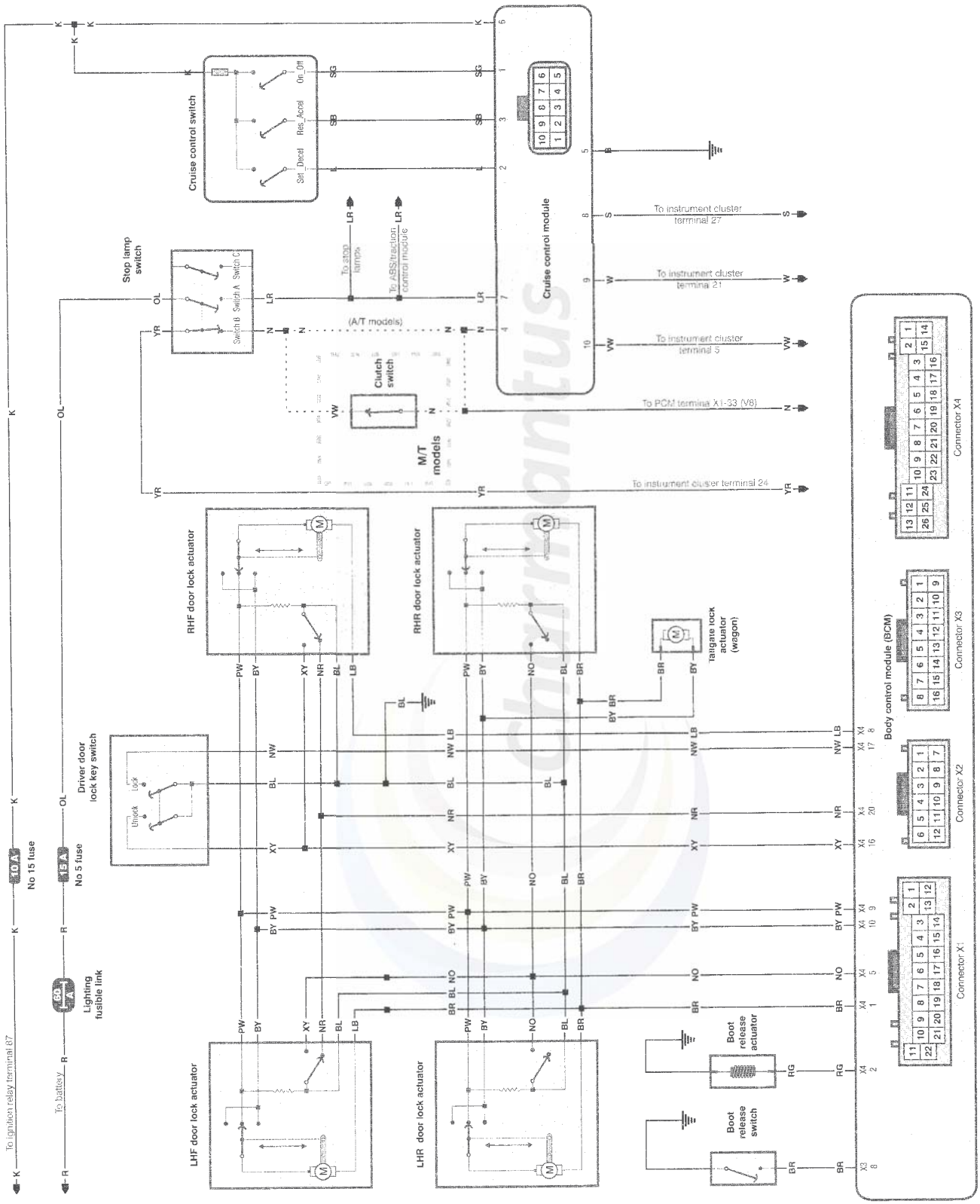
Stop lamps, turn signal, reverse lamps circuits. VY models



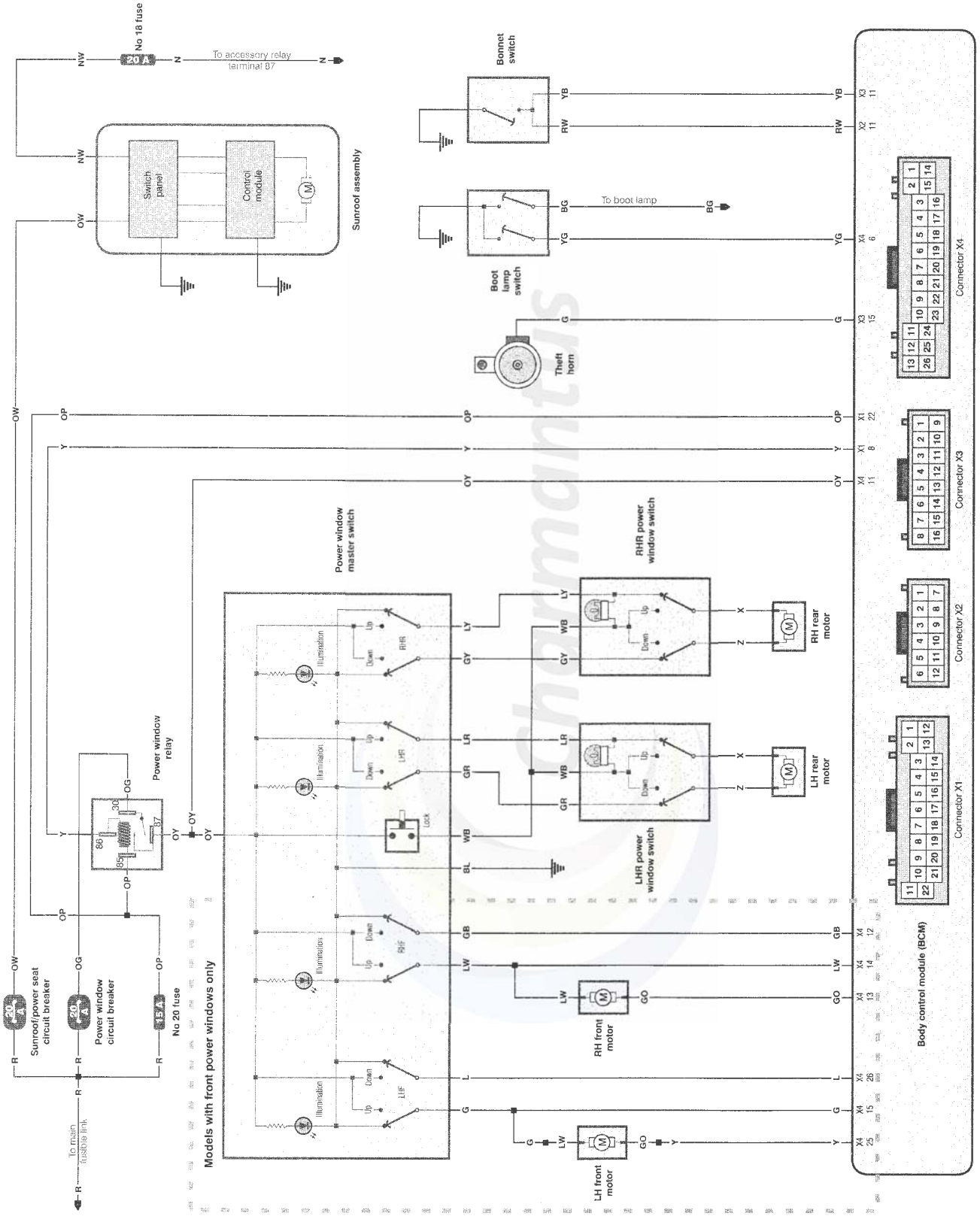
Interior lighting. VY models



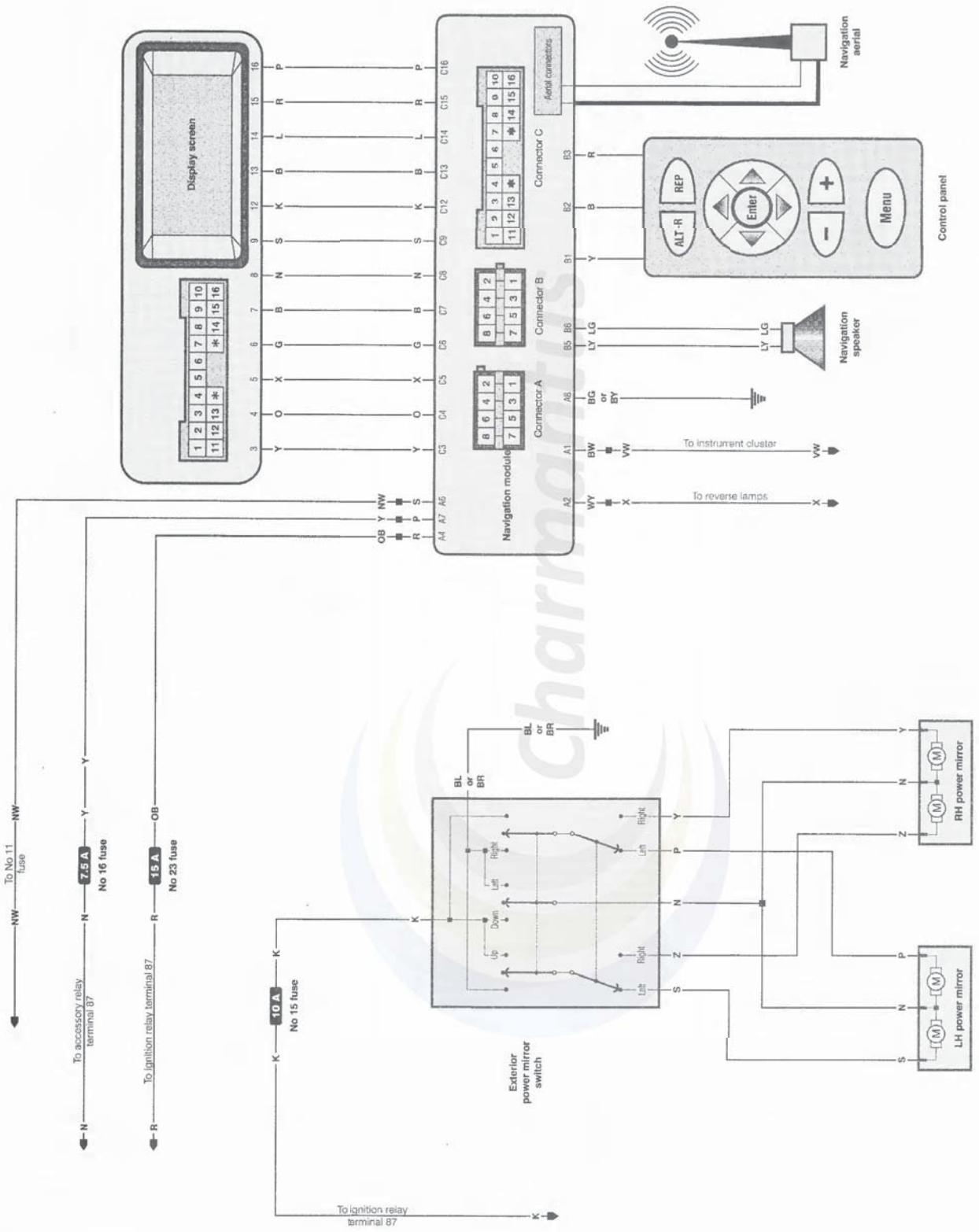
Windscreen wiper and washers. VY models



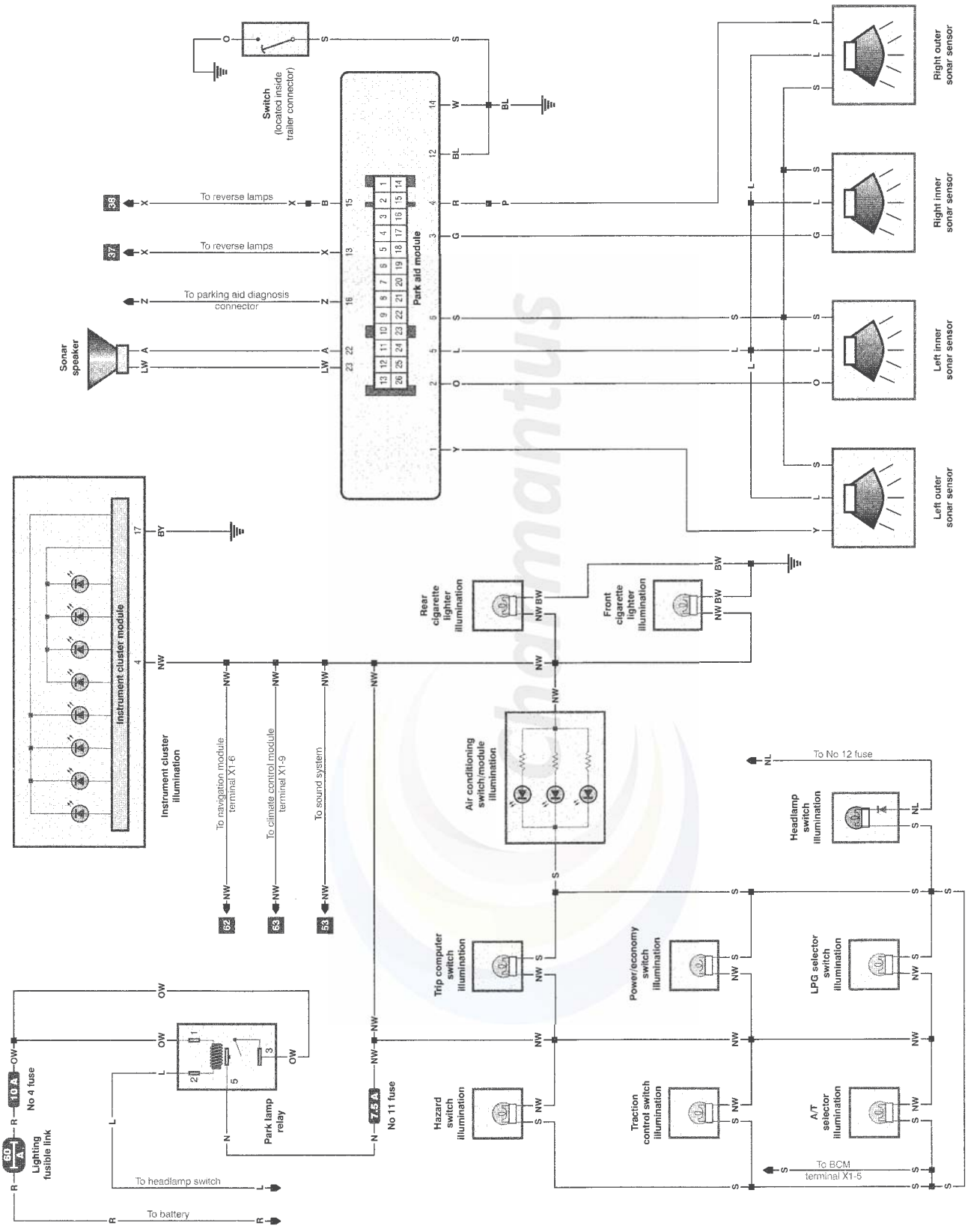
Power door locks, cruise control. VY models



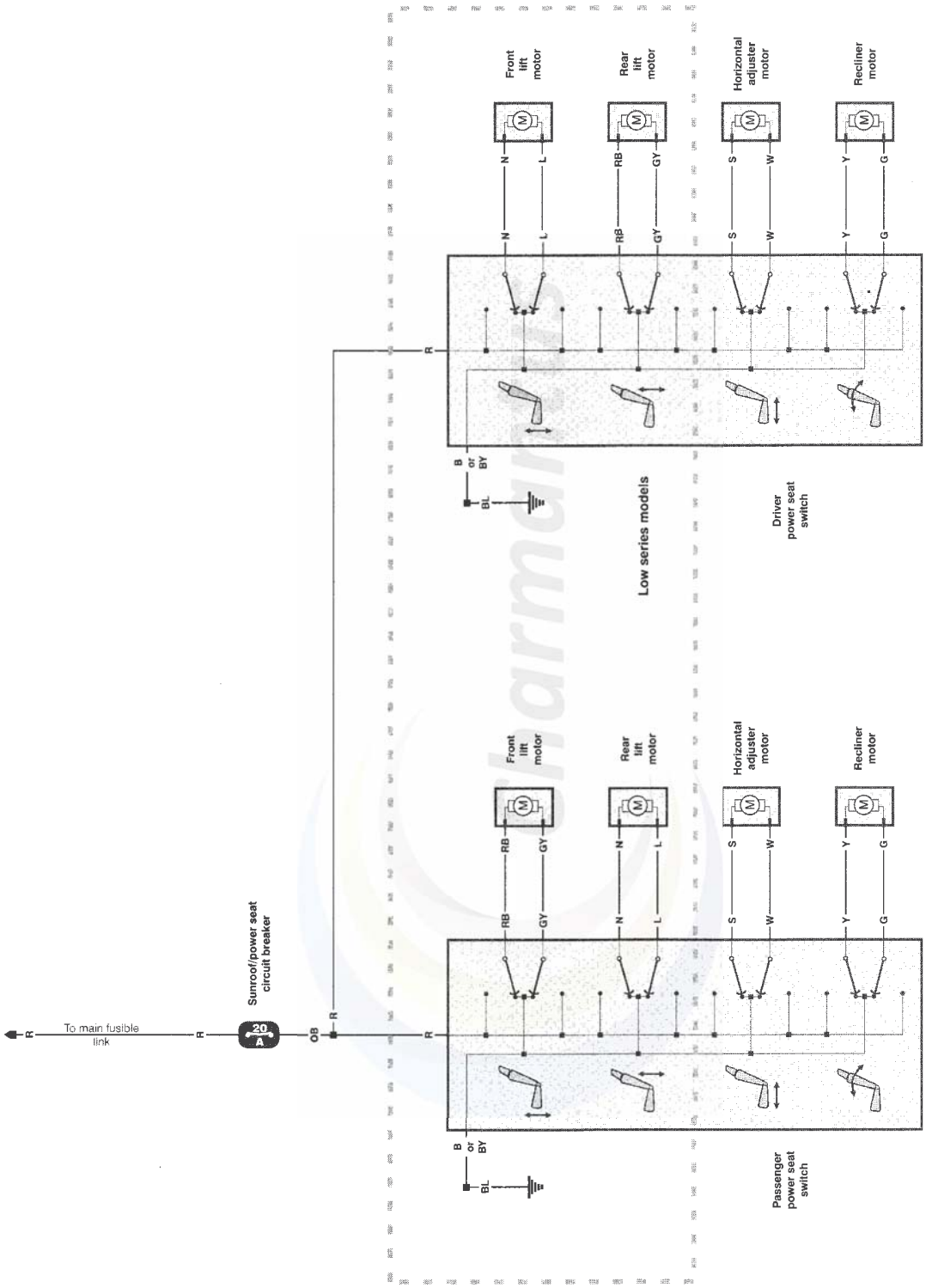
Power windows, sunroof, theft detterent system. VY models



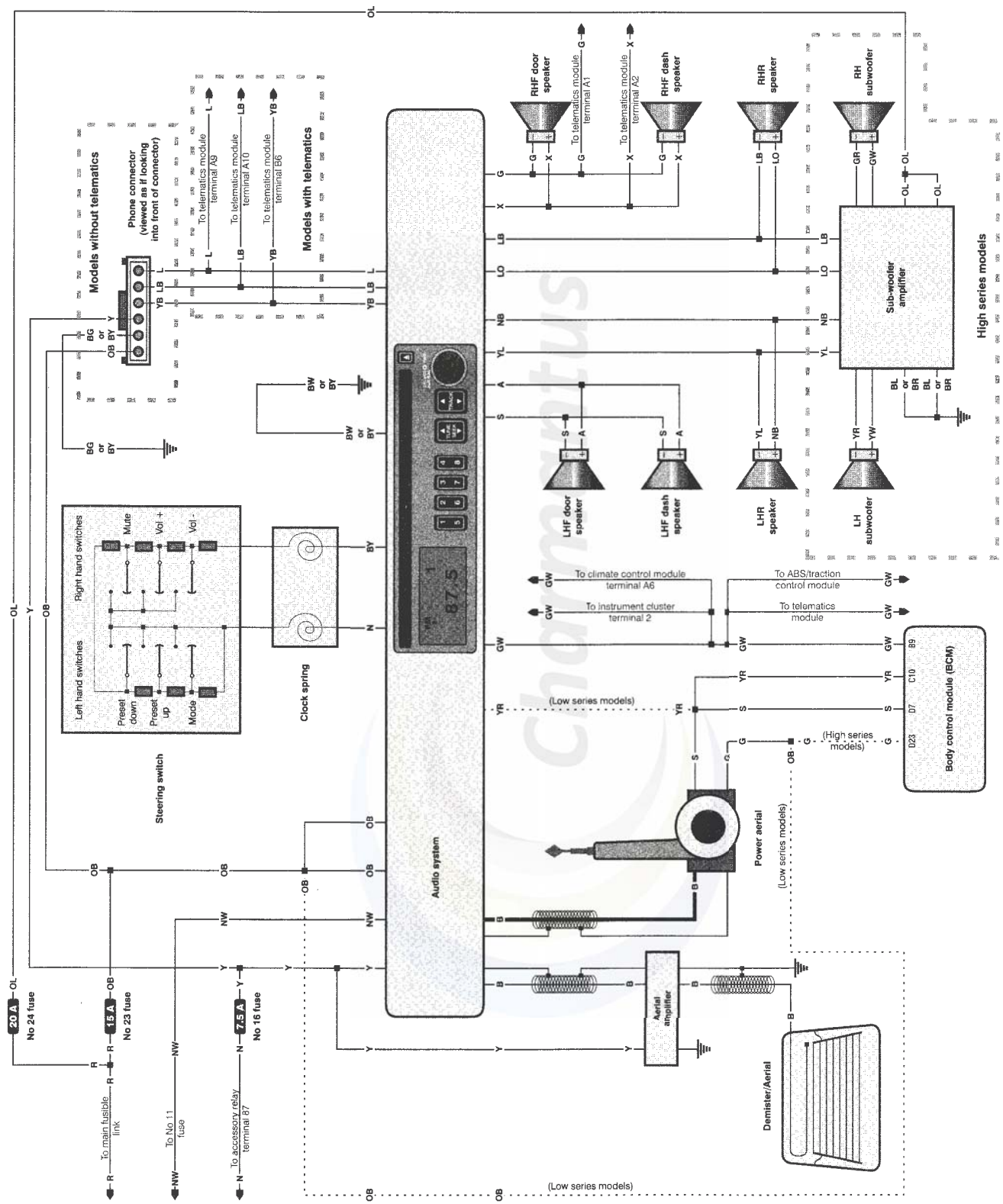
Power mirrors, satellite navigation system. VY models



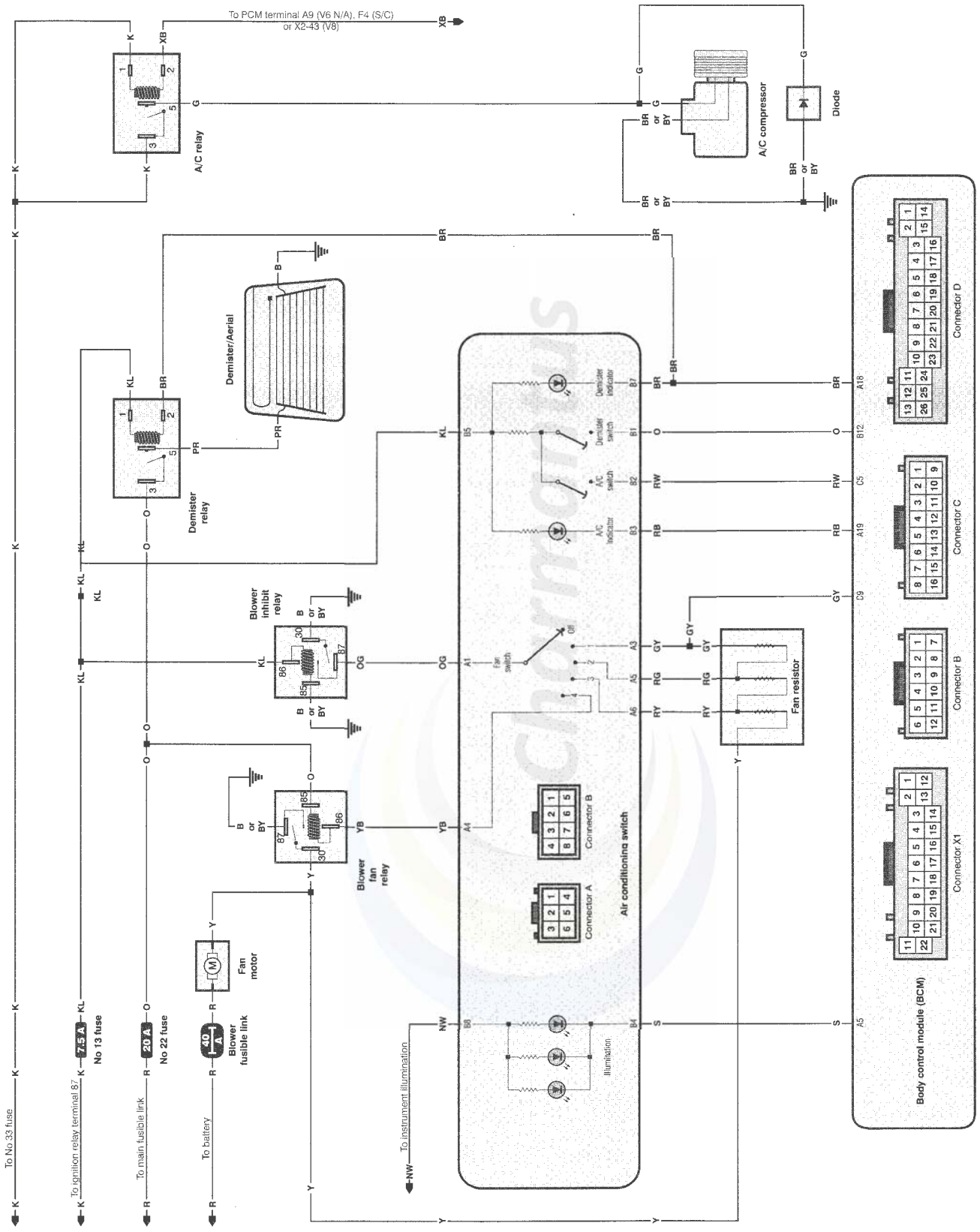
Instrument lighting, parking sensor. VY models



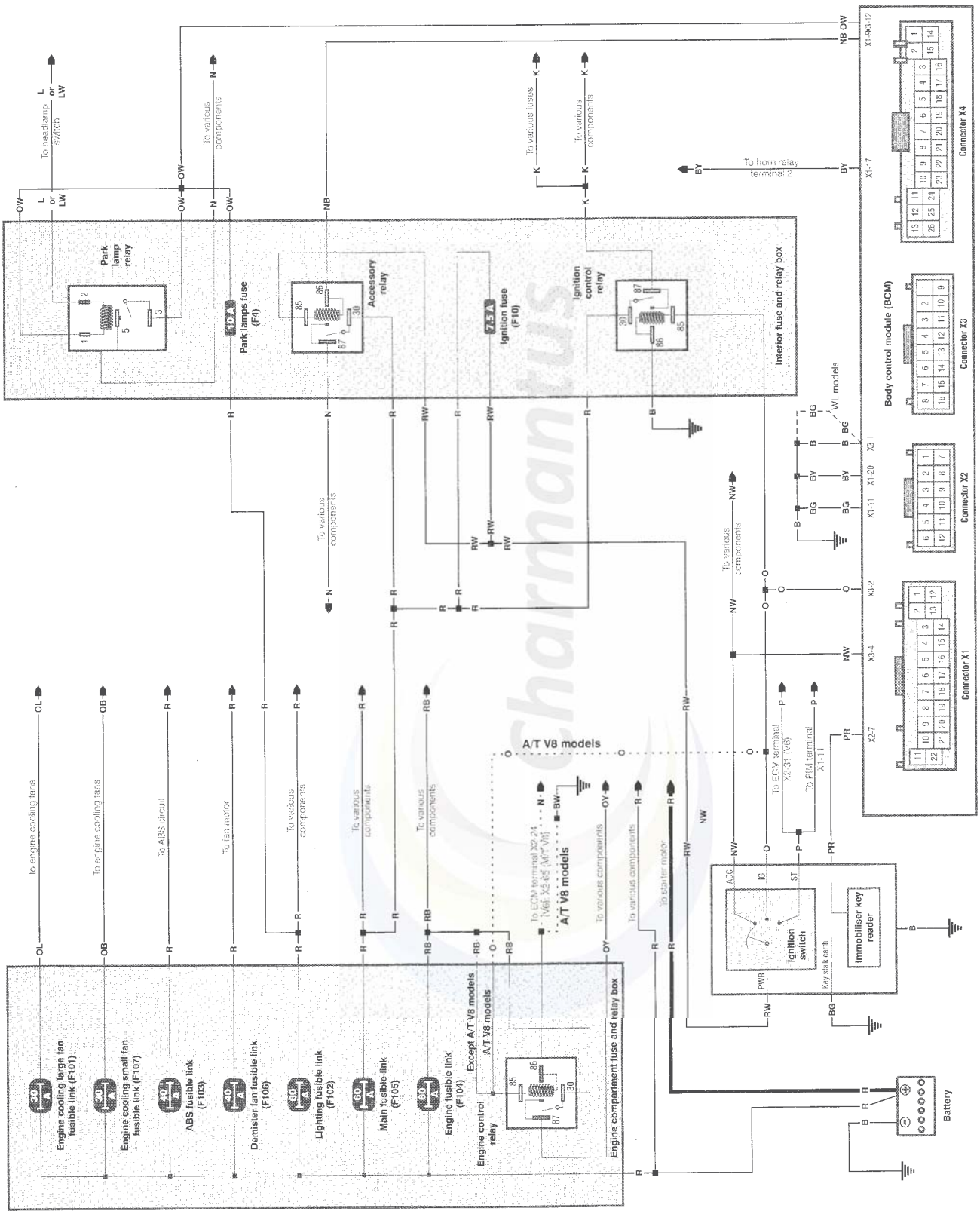
Power seats. VY models



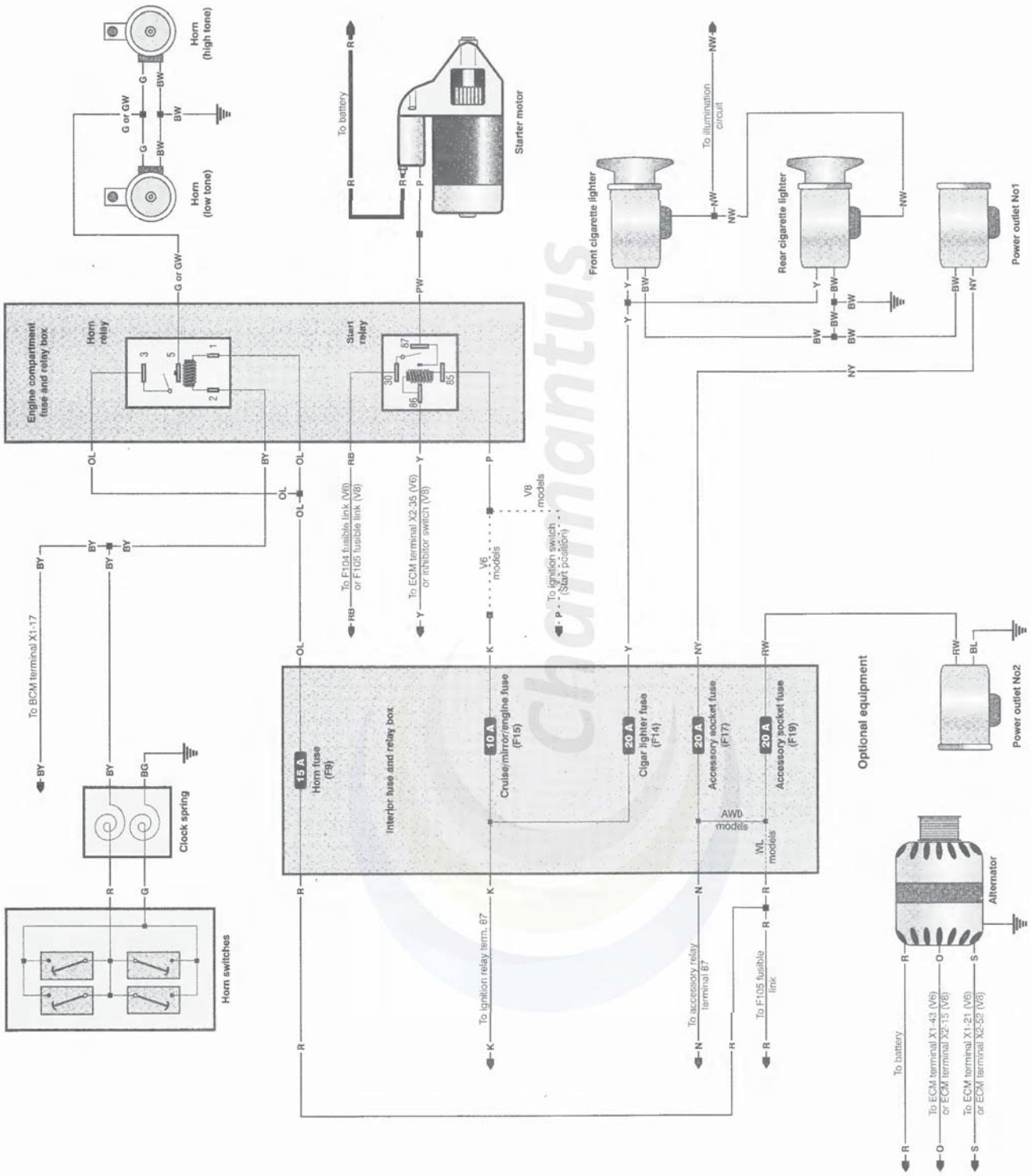
Audio system. VY models



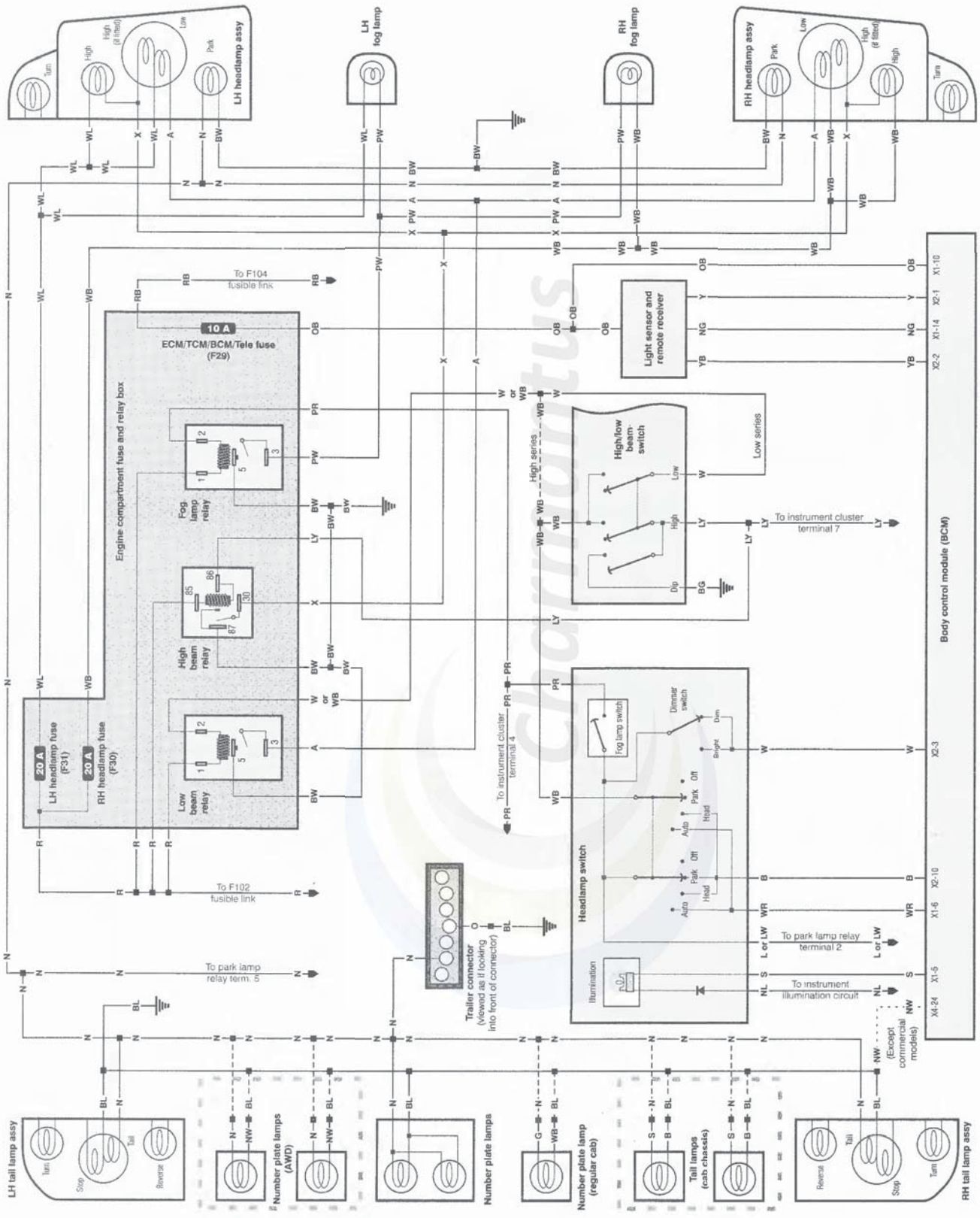
A/C, demister. VY models



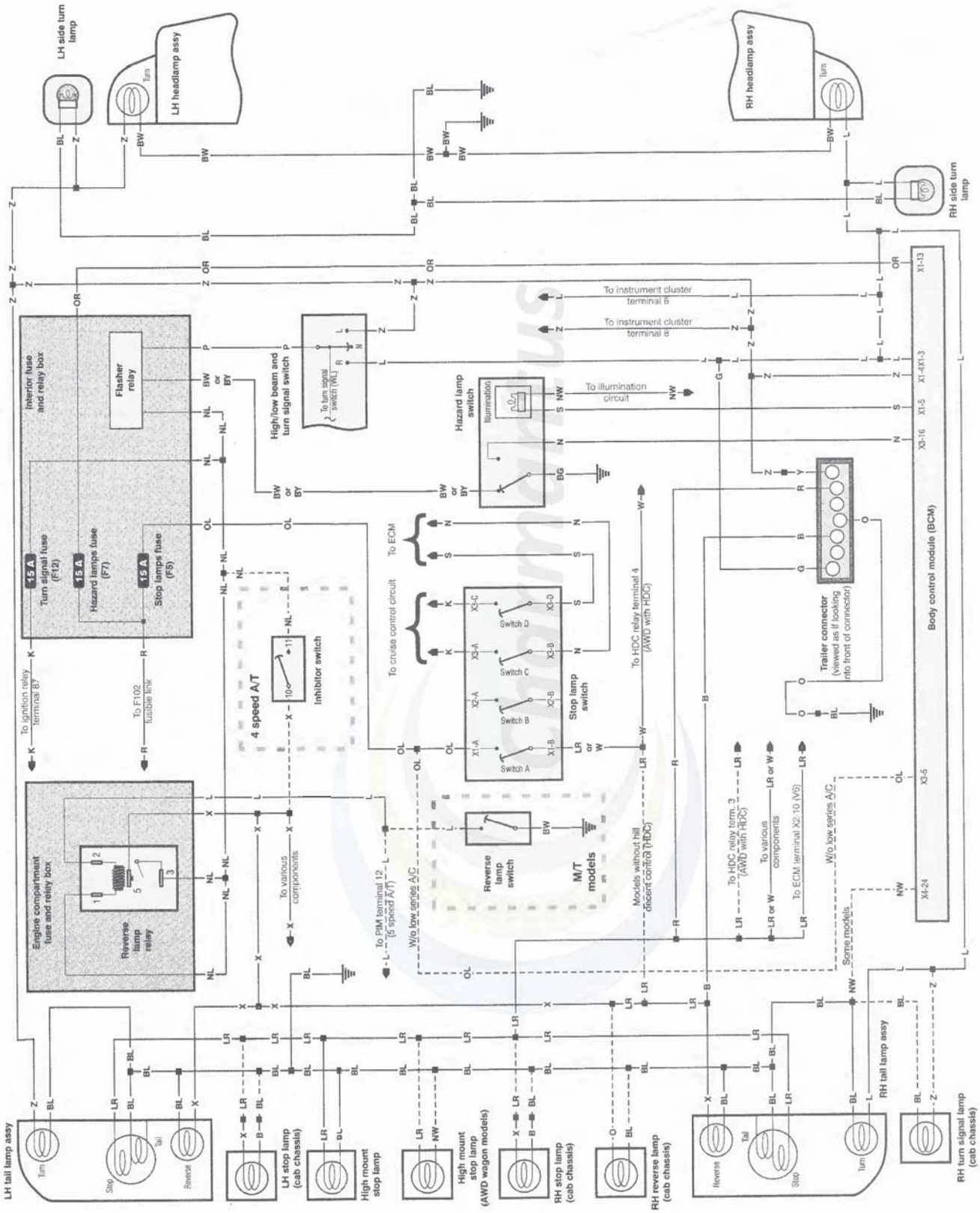
Power distribution. VZ models



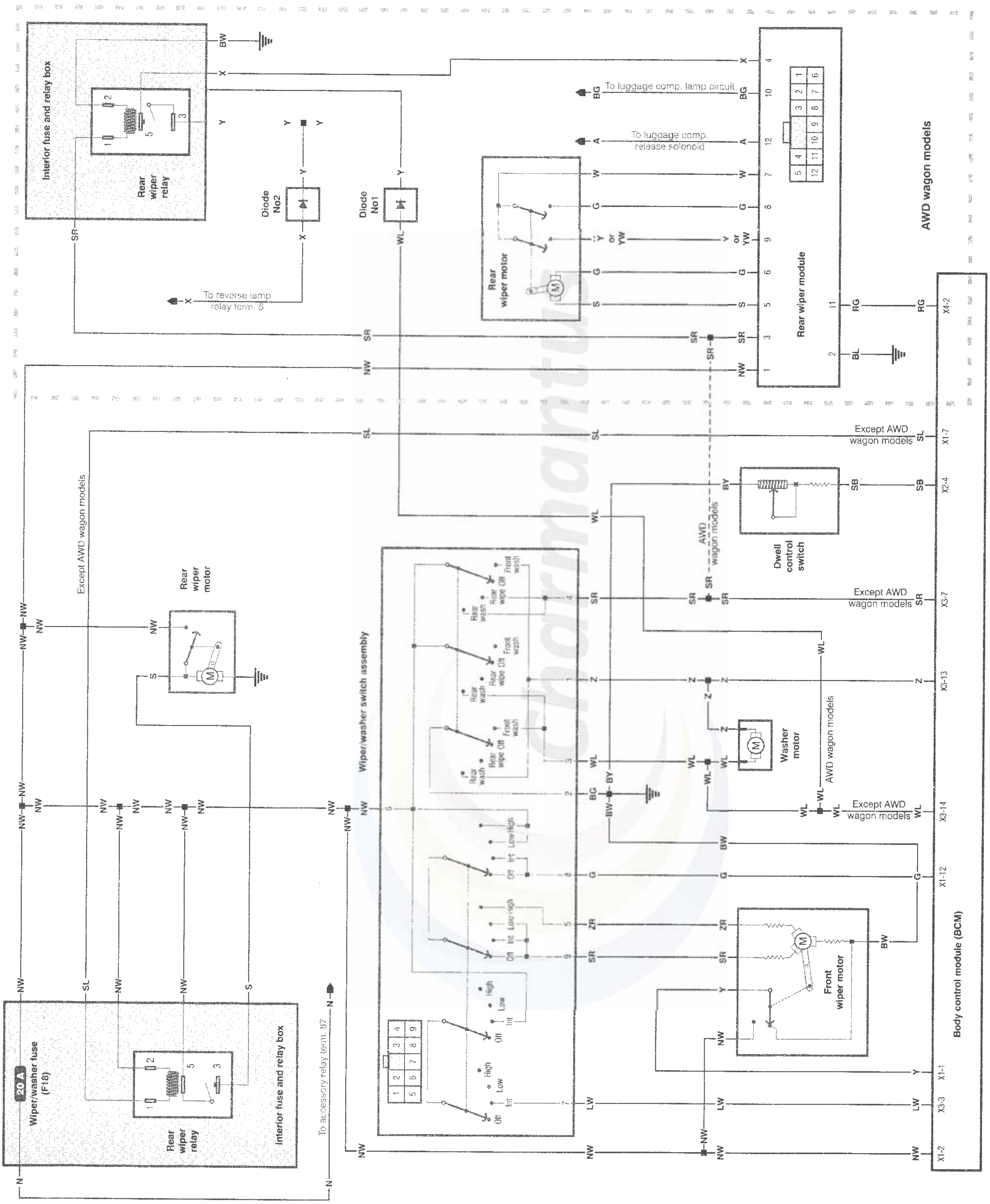
Starting and charging circuits, horn, power outlets. VZ models



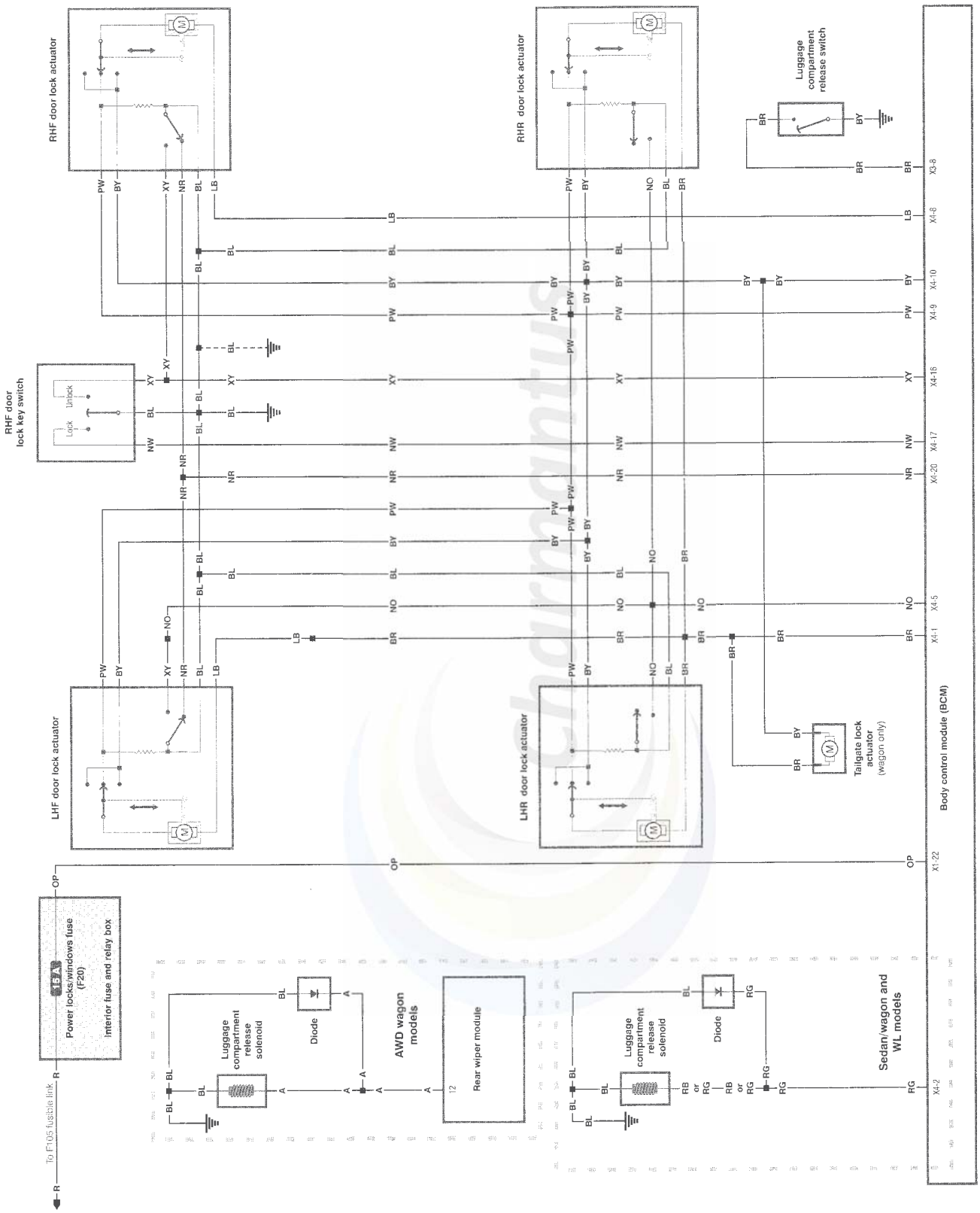
Headlamps, park lamps, reverse lamps, fog lamp circuits. VZ models



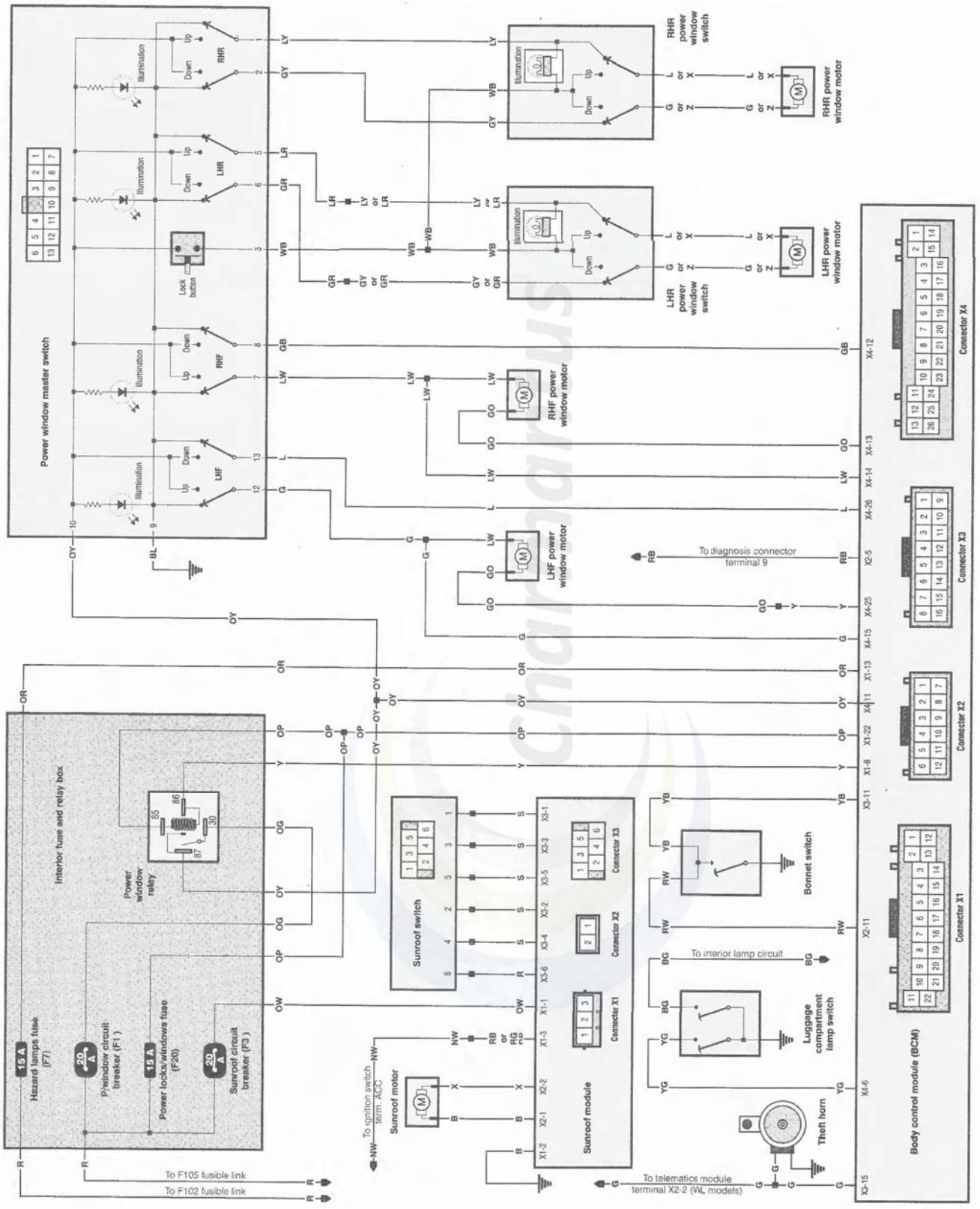
Stop lamps, turn signal, reverse lamp circuits. VZ models



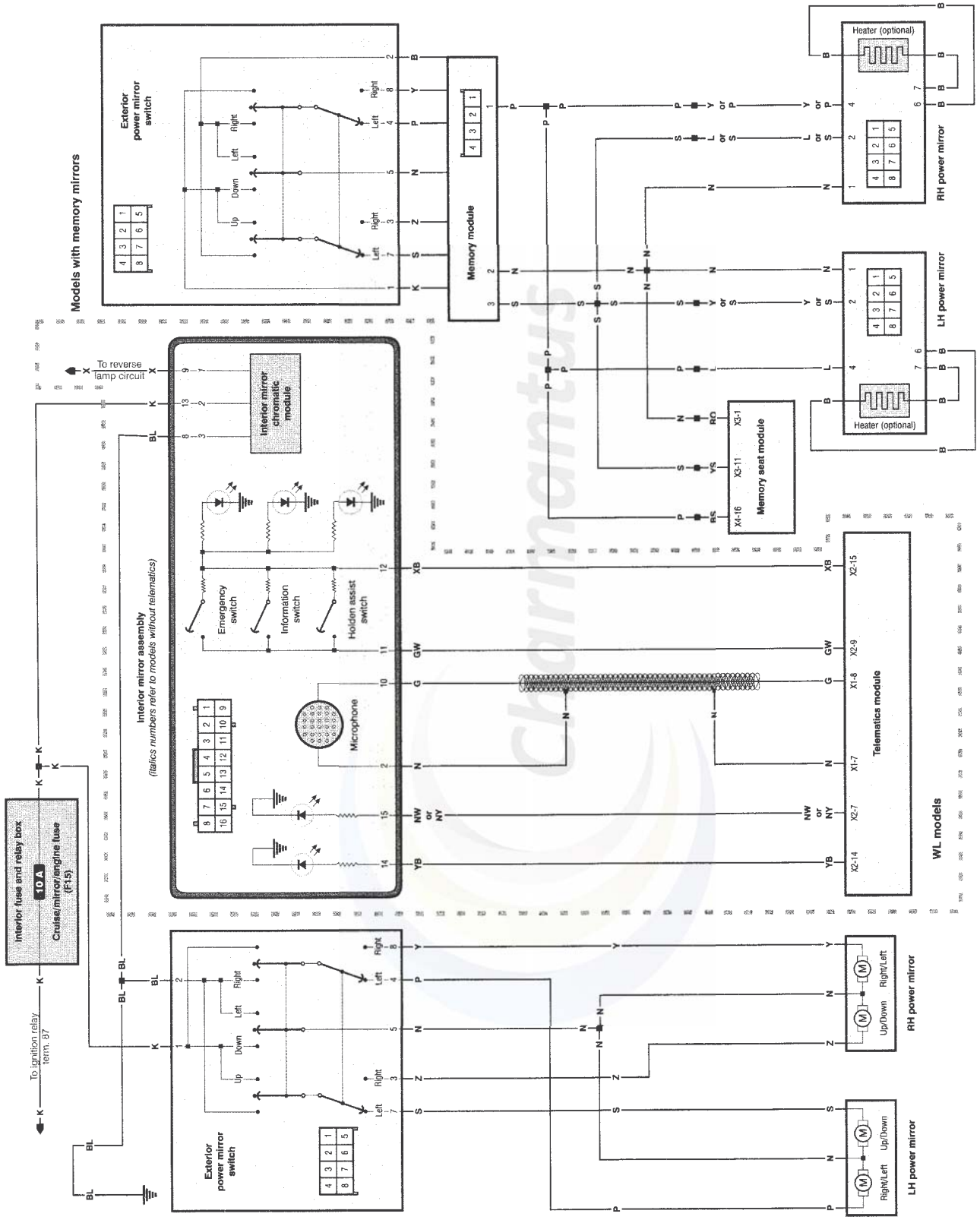
Windscreen wiper and washers. VZ models



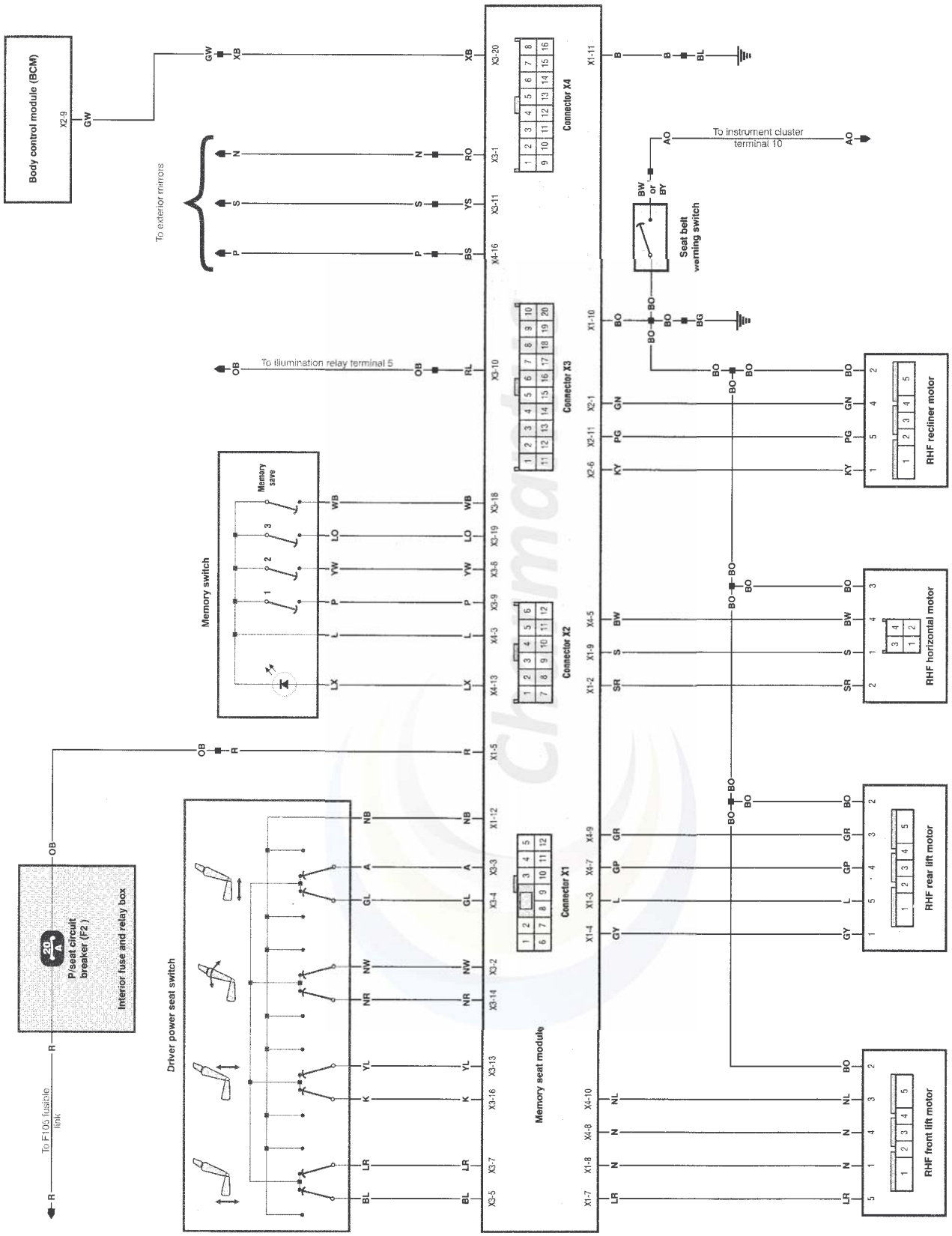
Power door locks. VZ models



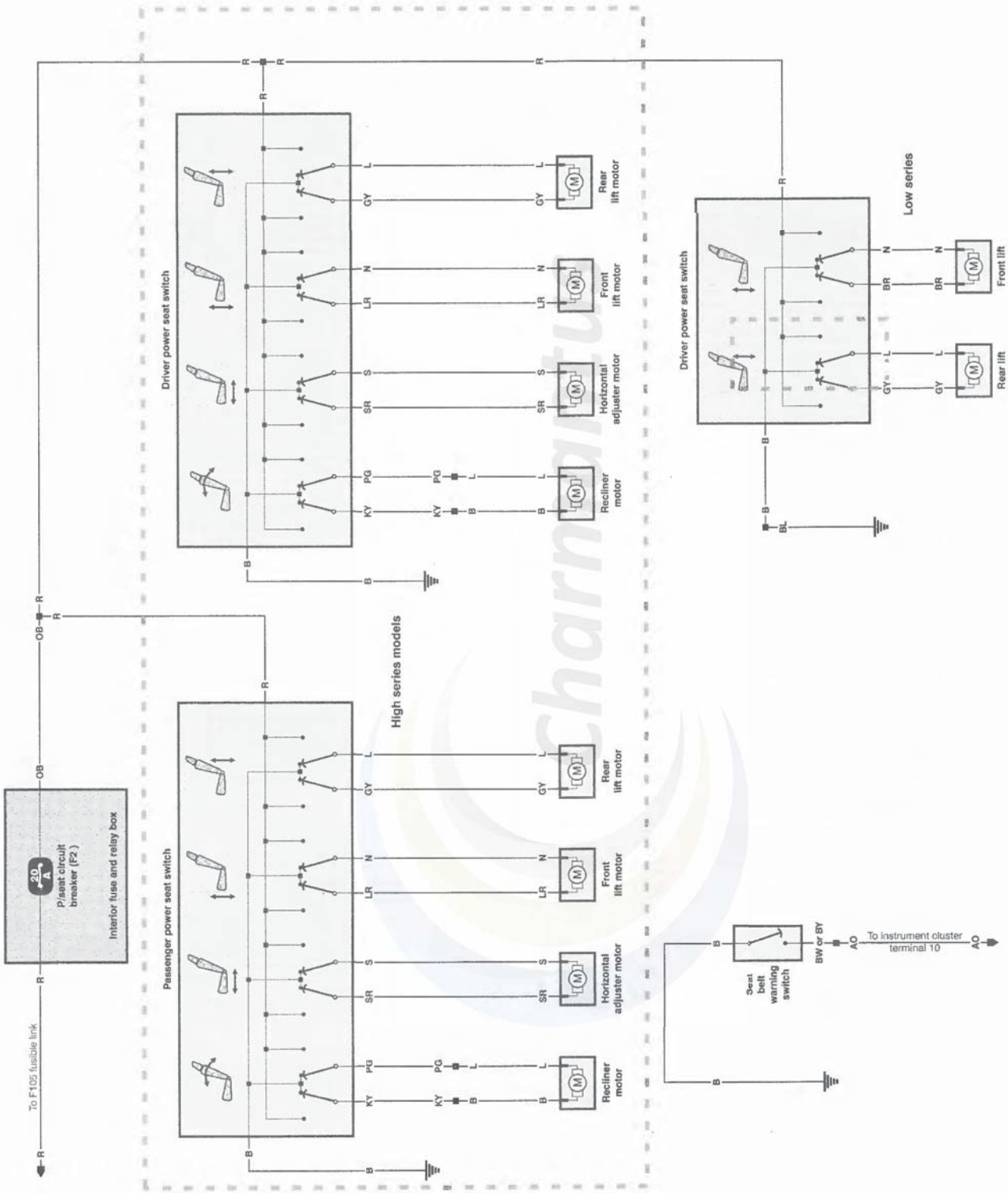
Power windows, sunroof, theft detterent system. VZ models



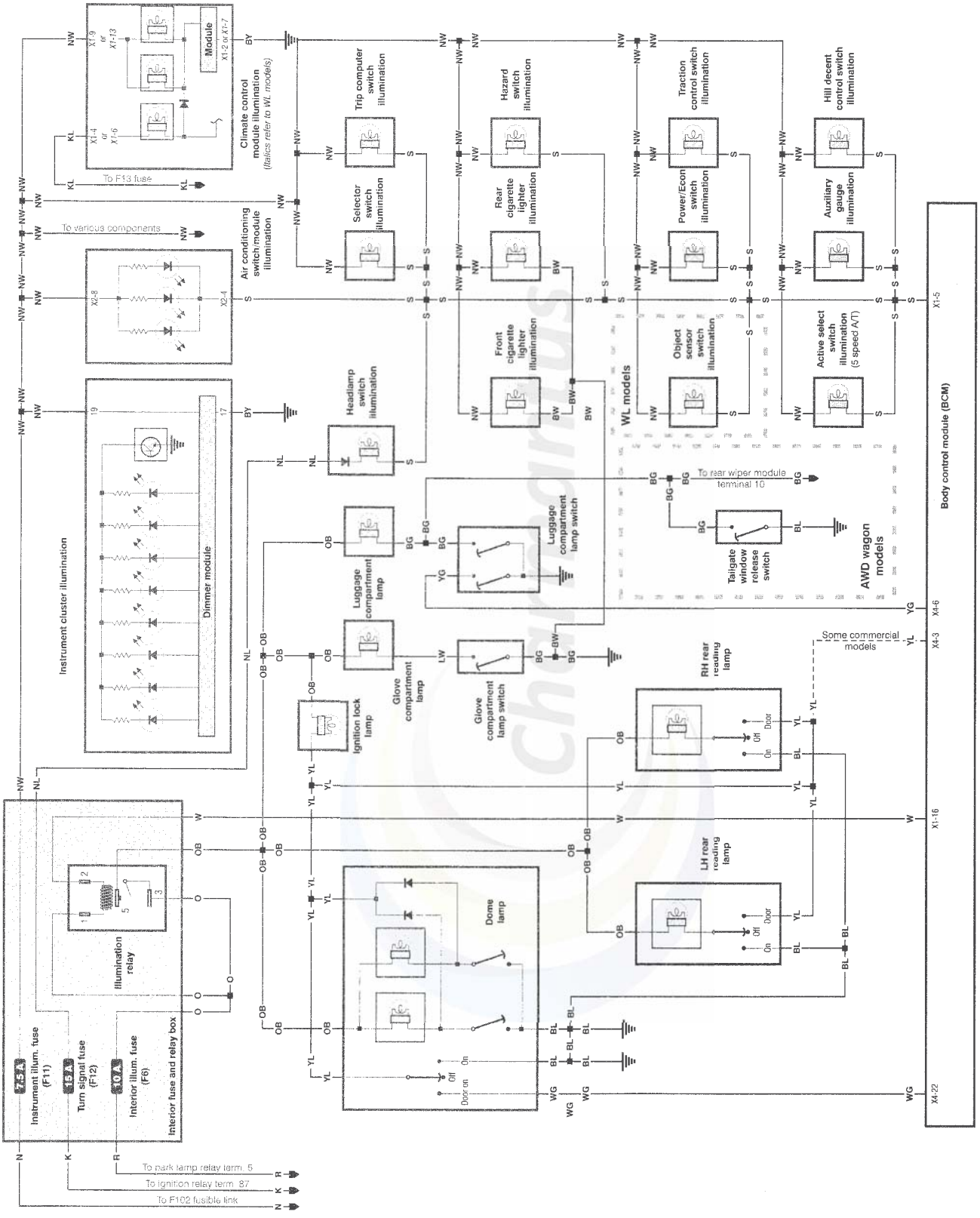
Power mirrors, telematics. VZ models.



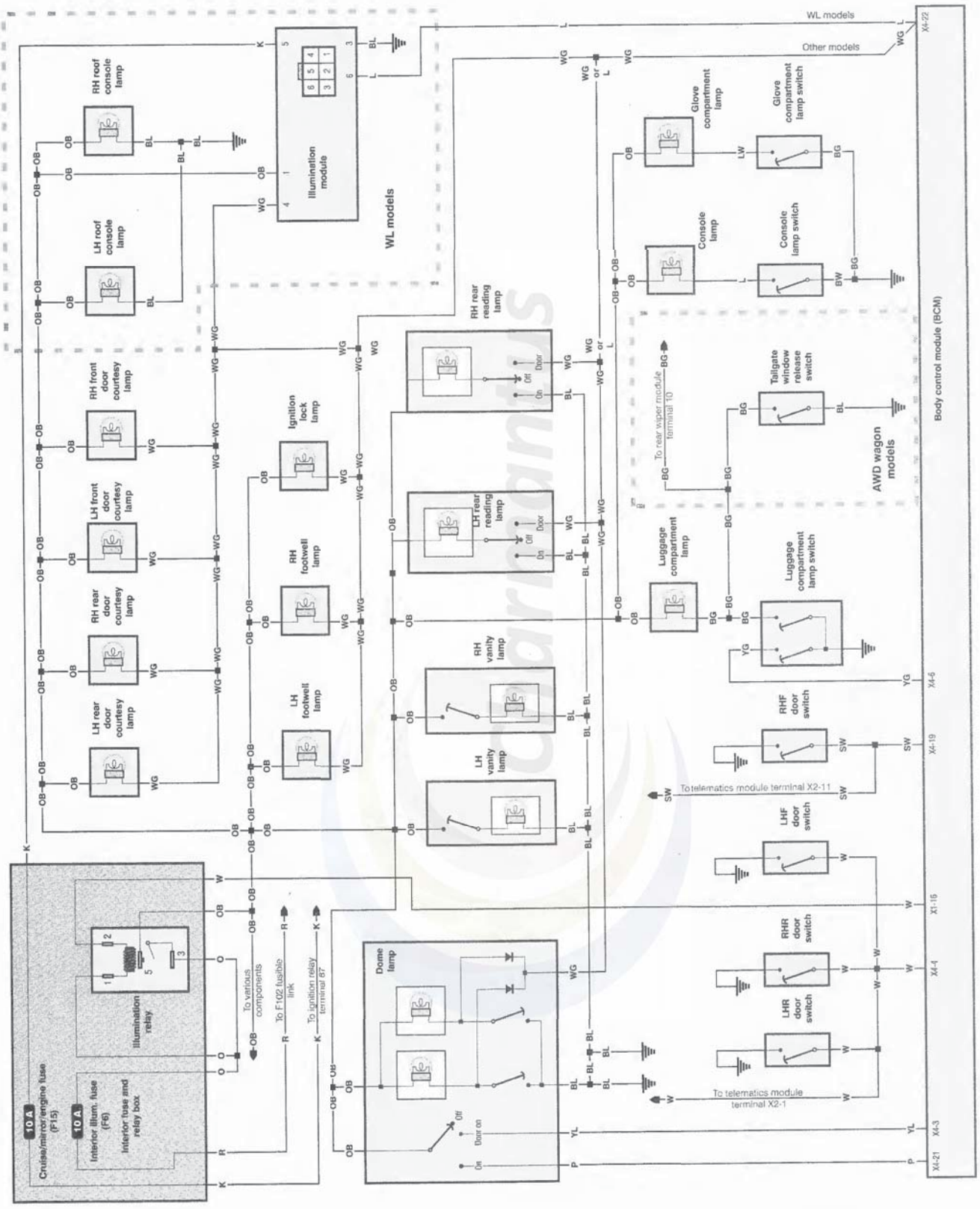
Power seats, with memory. VZ models.



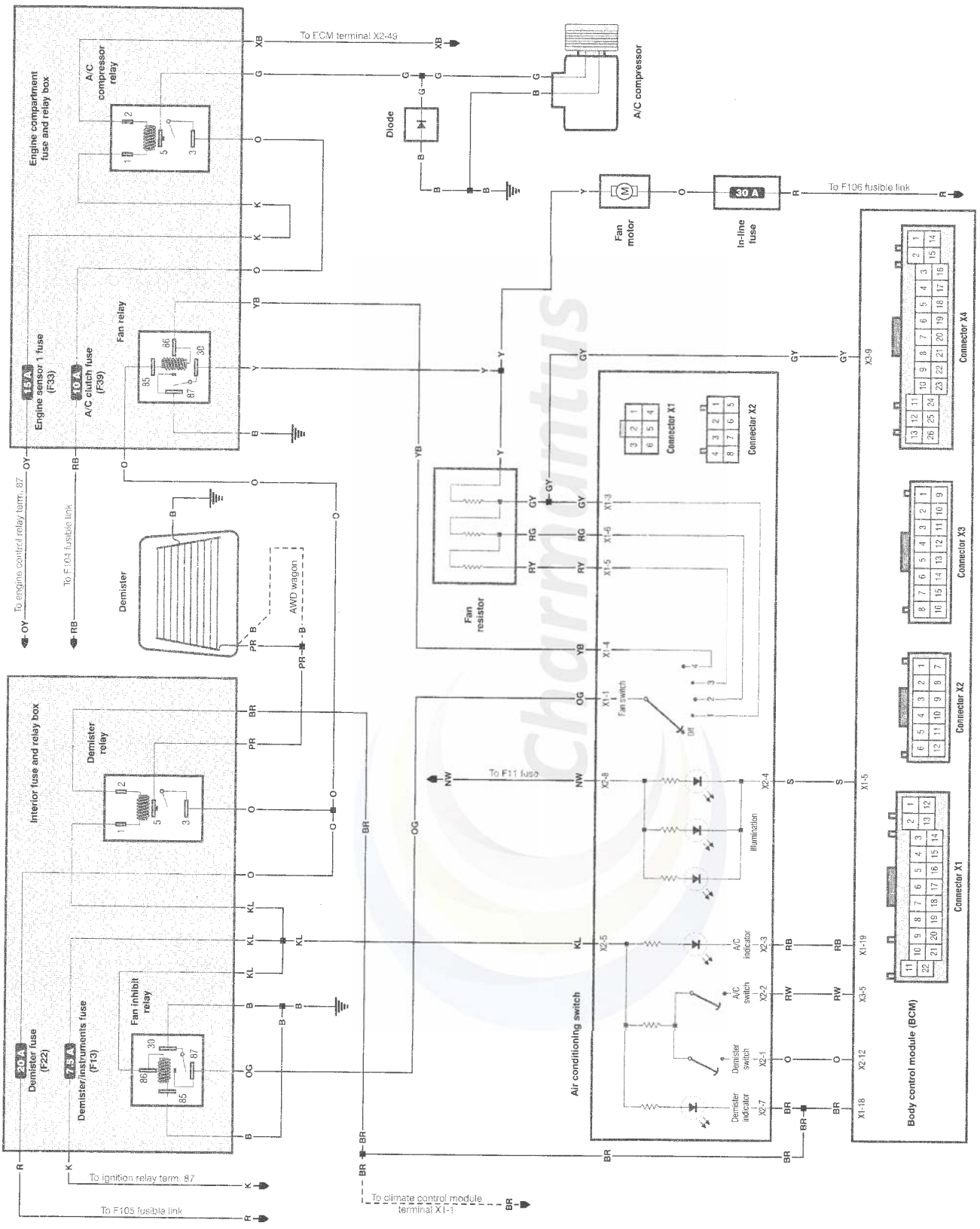
Power seats. VZ models.



Interior lighting and instrument lighting. VZ Executive models



Interior lighting and instrument lighting. VZ Berlina, Calais models



A/C, demister. VZ models