411
OWNERS WORKSHOP MANUAL

Volkswagen 411, 411 LE 1968-72

Autobook 865

By Kenneth Ball

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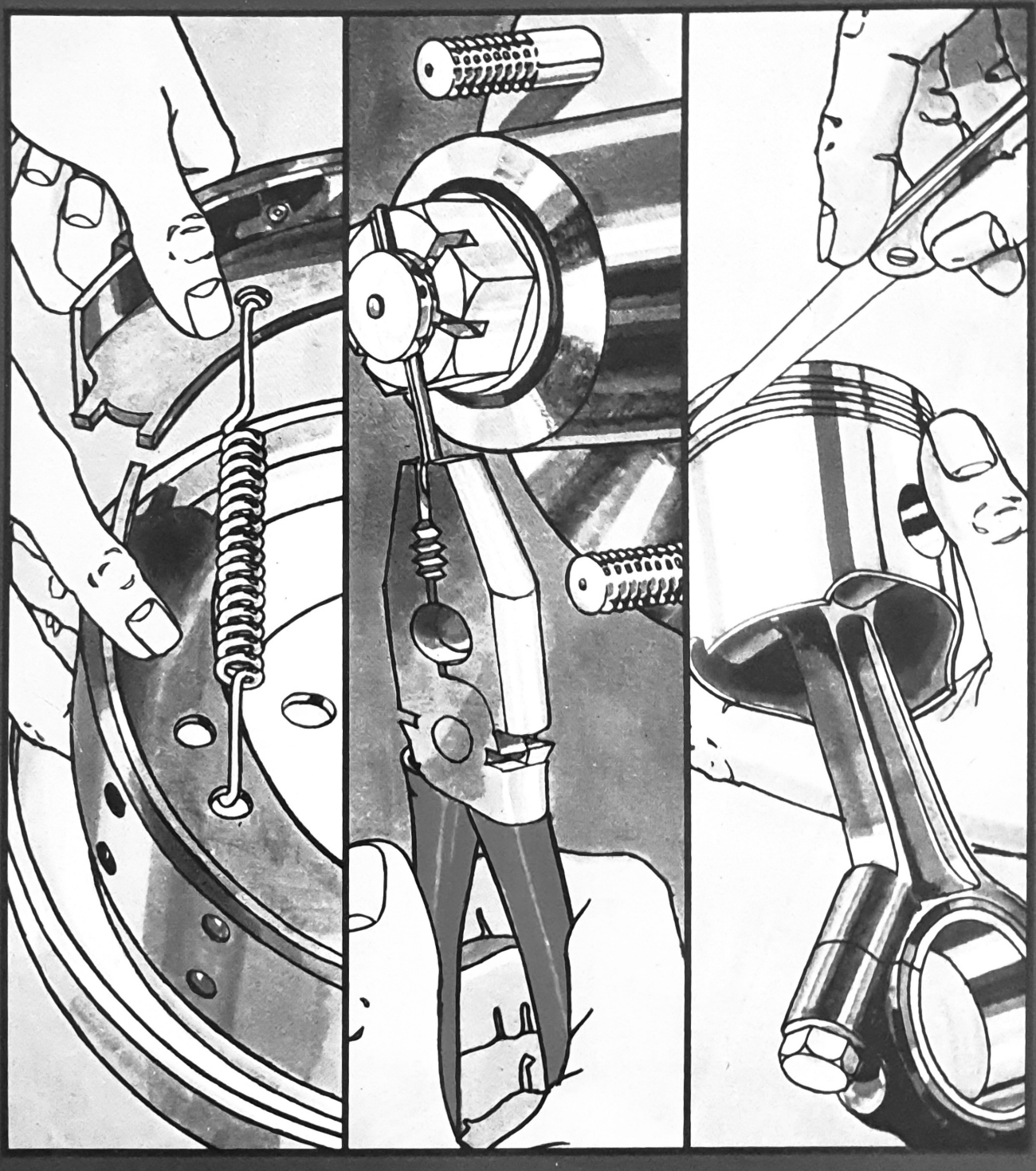

Autobooks

Volkswagen 411 1968-72 Autobook

By Kenneth Ball
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and the Autopress Team of Technical Writers.

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My thanks are due to Volkswagen Motors Ltd for their unstinted co-operation and also for supplying data and illustrations.

I am also grateful to a considerable number of owners who have discussed their cars at length and many of whose suggestions have been included in this manual.

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INTRODUCTION

This do-it-yourself Workshop Manual has been specially written for the owner who wishes to maintain his car in first class condition and to carry out his own servicing and repairs. Considerable savings on garage charges can be made, and one can drive in safety and confidence knowing the work has been done properly.

Comprehensive step-by-step instructions and illustrations are given on all dismantling, overhauling and assembling operations. Certain assemblies require the use of expensive special tools, the purchase of which would be unjustified. In these cases information is included but the reader is recommended to hand the unit to the agent for attention.

Throughout the Manual hints and tips are included which will be found invaluable, and there is an easy to follow fault diagnosis at the end of each chapter.

Whilst every care has been taken to ensure correctness of information it is obviously not possible to guarantee complete freedom from errors or to accept liability arising from such errors or omissions.

Instructions may refer to the righthand or lefthand sides of the vehicle or the components. These are the same as the righthand or lefthand of an observer standing behind the car and looking forward.

CHAPTER 1

THE ENGINE

1:1 Description

All the models covered by this manual follow the standard Volkswagen practice of having a flat four air-cooled engine mounted in the rear of the car. The engine is bolted to and mounted directly behind the combined transmission and final drive unit.

Sectioned views of the engine are shown in **FIG 1:1**. The crankcase is made up of two light-alloy castings bolted together in the vertical plane. The lower portion of the castings forms the oil pan and there is no separate sump. The castings are machined to take the four main bearing crankshaft as well as the camshaft immediately below it. One crankcase casting, the crankshaft and connecting rods, camshaft and associated parts are shown in **FIG 1:2**. The crankshaft has four throws and each piston therefore has its own throw. The cylinders and cylinder heads are bolted down on studs to the crankcase and by offsetting the pairs of cylinders adequate clearance is given between the connecting rods. Renewable bearing inserts are used for the crankshaft and camshaft bearings. The design gives a very short crankshaft which, combined with the four main bearings, gives a very rigid structure.

Individual cylinders are fitted, deeply finned to allow for cooling, and each pair of cylinders is fitted with a single cylinder head. Overhead valves are fitted and these are operated using rocker arms (pivoting on a rocker shaft), pushrods, and tappets from the centrally mounted single camshaft. The tappets (cam followers) move in machined bores in the crankcase casting while the push-rods operate in tubes between cylinder head and crank-case. The camshaft is driven directly by gears from the crankshaft.

A schematic view of the lubrication system is shown in **FIG 1:3**. The oil is contained in the lower portion of the crankcase castings. Note that the base is deeply finned to allow for oil cooling. A gear type oil pump draws the oil from the oil pan and supplies it under pressure to the engine. Oil to the pump passes through a strainer, accessible from under the engine, to ensure that large particles are not drawn into the pump. The oil under pressure passes from the pump through a fullflow filter element, which is renewable, before passing to the engine or oil cooler. A ball valve is fitted to the oil filter so that in the event of the element becoming choked a supply of oil will still pass to the engine. Relief valve assemblies are fitted, which serve the double purpose of controlling the oil flow through the oil cooler and limiting the maximum pressure in the system. When the engine is cold and the

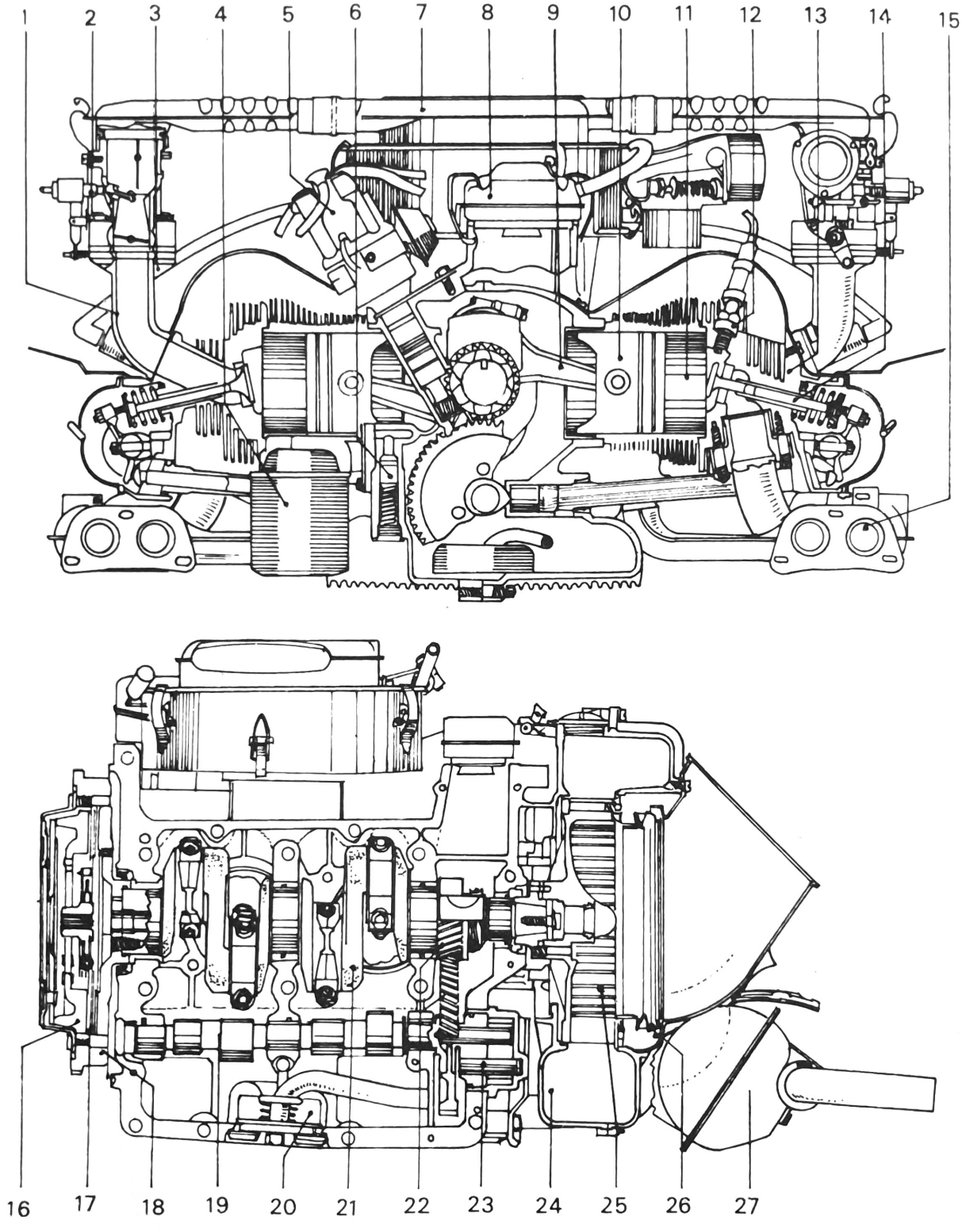


FIG 1:1 Sectioned views of the engine

Key to Fig 1:1 1 Induction pipe 2 Carburetter 3 Balance pipe 4 Oil filter 5 Ignition distributor 6 Oil pressure relief valve 7 Air cleaner 8 Crankcase breather 9 Connecting rod 10 Piston 11 Cylinder 12 Spark plug 13 Cylinder head 14 Valve 15 Heat exchanger 16 Clutch 17 Clutch driven plate 18 Flywheel 19 Camshaft 20 Oil strainer 21 Crankshaft 22 Camshaft drive gear 23 Oil pump 24 Fan housing 25 Fan 26 Fan belt pulley 27 Silencer (muffler)

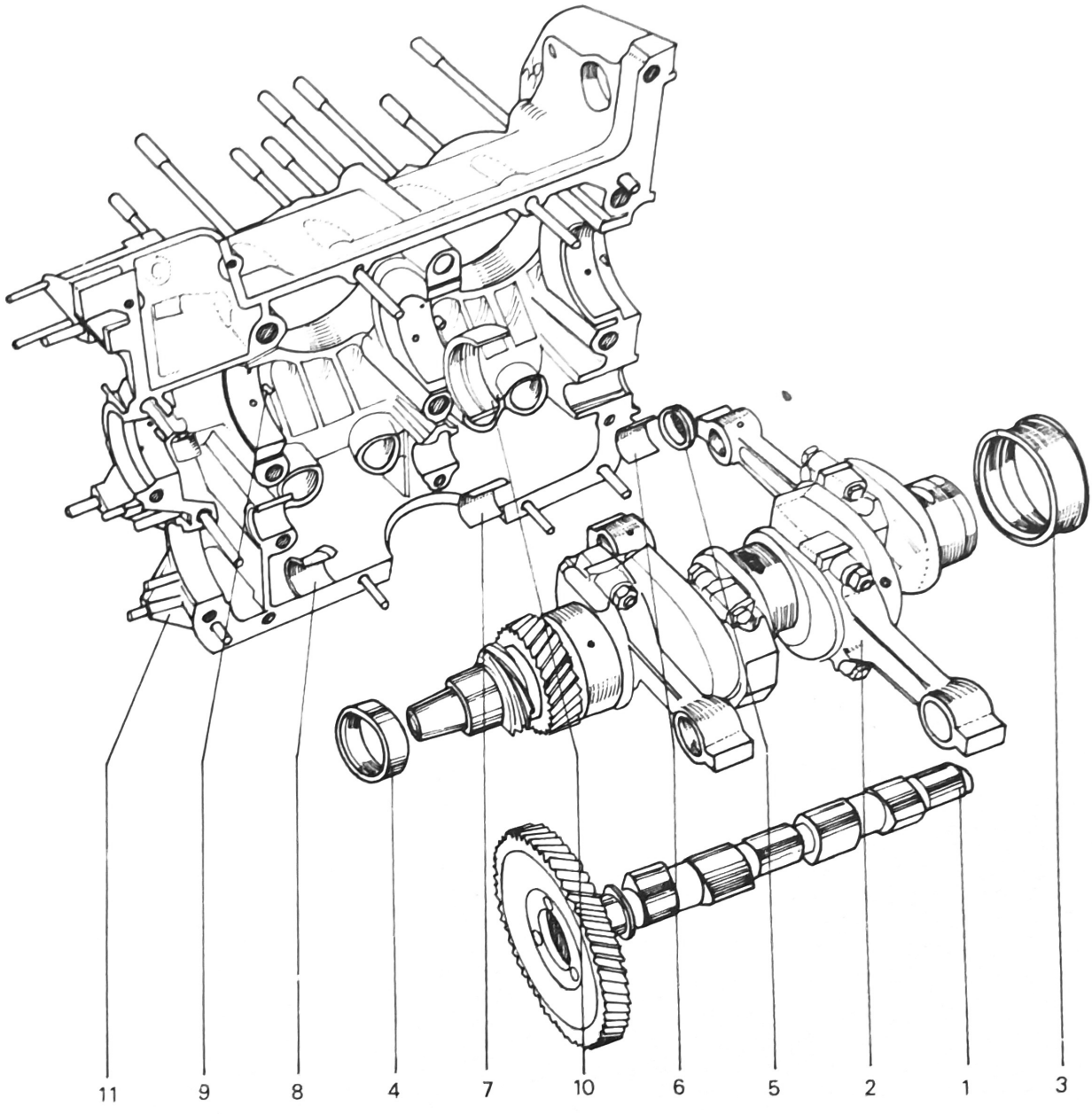


FIG 1:2 The crankshaft, camshaft and one crankcase casting

Key to Fig 1:2 1 Camshaft 2 Crankshaft with connecting rods 3 No. 1 main bearing 4 No. 4 main bearing 5 Camshaft bore end cover 6 No. 1 camshaft bearing shell 7 No. 2 camshaft bearing 8 Lefthand shell for No. 3 camshaft bearing 9 Crankshaft bearing dowel 10 No. 2 crankshaft bearing shell 11 Lefthand crankcase half

pressure is high, both relief valves have their pistons pressed down against their springs by the oil pressure. The upper valve allows the oil to bypass the oil cooler to ensure more rapid warming-up of the engine. The lower relief valve allows surplus oil to return directly to the oil pan and limits the maximum pressure in the system. As the oil warms up the pressure drops and allows the upper valve to close, so that the oil passes through the oil cooler. The lower valve will still limit the maximum pressure in the system. Oil galleries and internal passages then lead the oil to the crankshaft main bearings, camshaft bearings and cam followers. The front main bearing is lubricated by a tapping from No. 2 bearing and the big-end bearings are lubricated from the main bearings by passages drilled through the crankshaft. A metered supply of lubricant passes up the hollow pushrods to lubricate the rocker assembly, the oil then returning down the pushrod tubes. The remainder of the parts are lubricated by oil splash.

The oil pump is driven by the rear of the camshaft. The distributor is driven by gears from the crankshaft.

A cooling air impeller mounted on the rear of the crankshaft draws in air from outside and blows it over the engine. The engine is enclosed, as shown in **FIG 1:4**, and deflector plates guide the air over the fins. Thermo-

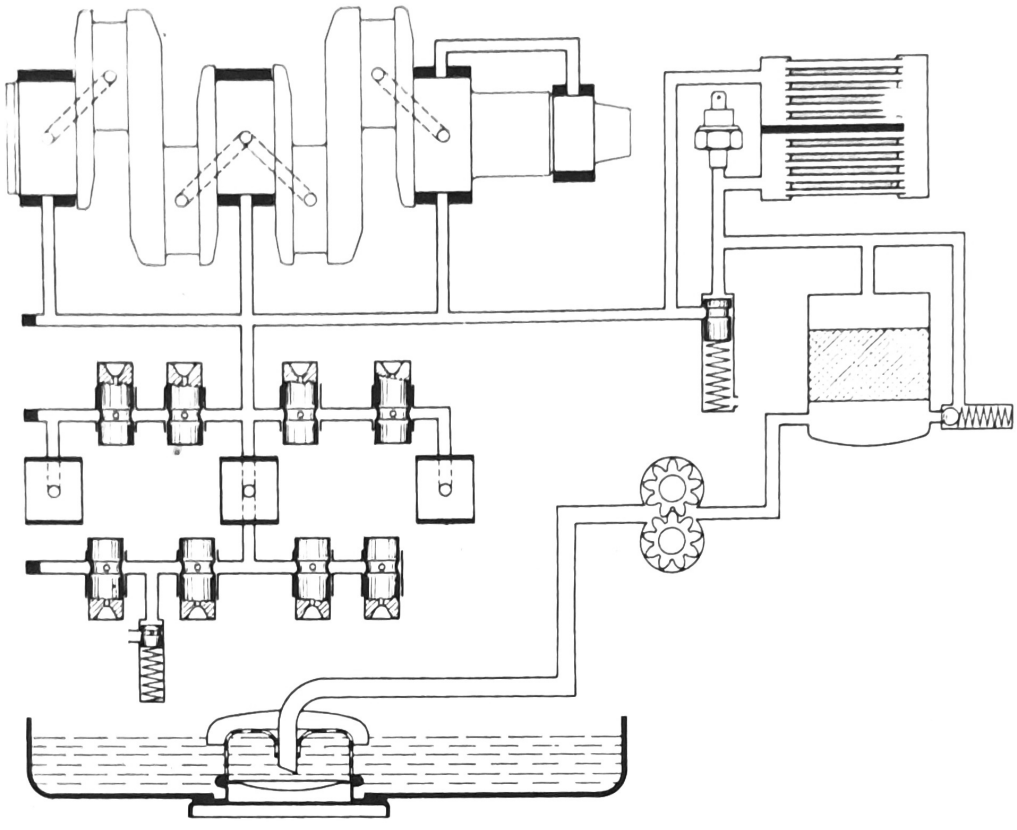


FIG 1:3 Schematic diagram of the engine lubrication system

statically controlled ducts control the amount of air drawn in, so that when the engine is cold rapid warm-up is ensured. Part of the cooling air passes through heat exchangers on the exhaust and is then used for heating the interior of the car.

1:2 Removing the engine

Removal of the engine on Volkswagen models is comparatively easy. Because of the design of the engine it will be found essential to remove it for many operations, more than are usual on a conventional engine.

If the owner is not a skilled automobile mechanic he is advised to read the **Hints on Maintenance and Overhaul** section in the **Appendix**, as this contains much useful information.

The car must be raised for the removal of the engine so **make sure that all supports used are strong enough and firmly based.** A trolley jack should be used for supporting the engine and for wheeling it out from under the car. A suitable adaptor, VW.612/4, is made for supporting the engine but if this is not available use a suitable plate and pieces of wood as packing to prevent damage to the engine. An assistant is required to steady parts and help in difficult operations.

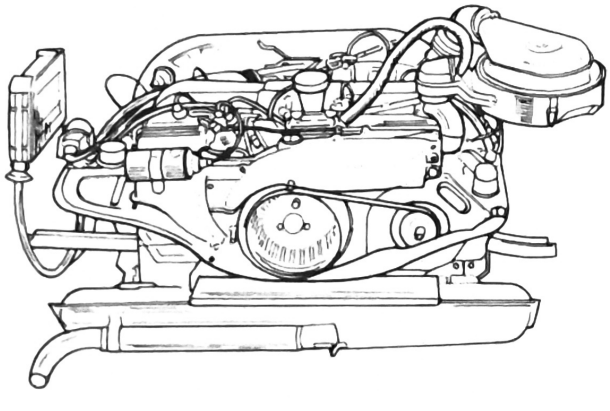


FIG 1:4 External view of the engine fitted with fuel injection

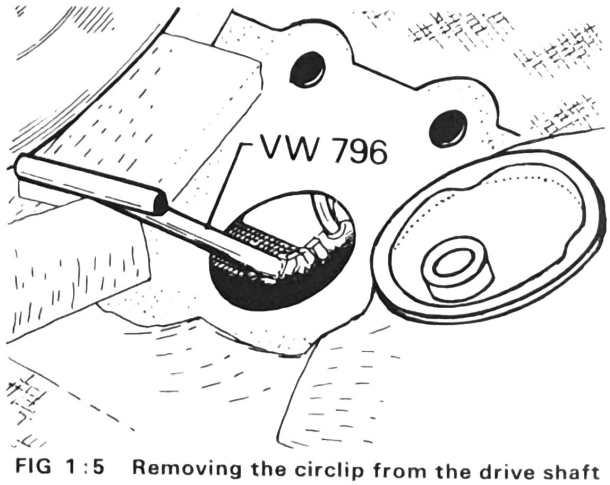


FIG 1:5 Removing the circlip from the drive shaft

Removal:

1 Disconnect both battery cables from the battery. The ground cable should be disconnected first and connected last to prevent any danger of shortcircuits. Note that the battery is under the front lefthand seat.

2 On all models remove the air cleaner. Disconnect all fuel system connections from the engine, noting that fuller details of both carburetter and fuel injection systems are given in **Chapter 2**. On models fitted with carburetters, disconnect the inlet line to the fuel pump (plugging it with a suitable plug to prevent fuel syphoning through) and disconnect the leads to the automatic chokes and idle valve solenoids. Label the leads and lay them safely out of the way. On models fitted with fuel injection, disconnect the electrical leads, after labelling any that are not obvious, and also disconnect the fuel ring main. On all models, disconnect the throttle linkage from the engine.

3 Disconnect the electrical leads to all other components on the engine. These components include the starter motor, alternator, ignition coil and oil pressure warning switch. Disconnect the primary lead and the HT lead from between the ignition coil and distributor. Unless the connections are perfectly obvious, leads should be labelled as they are disconnected. Too often only a mental note is made as they are disconnected, and if the colours have faded or become obscured with dirt there is great uncertainty about the correct connections when it comes to reassembly.

4 Remove the rear seat and take out the cover over the drive shaft. Remove the nut with the aid of the special wrench VW.796. Tap lightly on the tool to dislodge the circlip, as shown in **FIG 1 : 5**. Pull the shaft forward by approximately 100 mm (4 inch).

5 Remove the cooling air intake duct, warm air fan and associated parts such as cooling air intake valves and bellows, as well as hoses. Remove the engine compartment seal. Remove the shield for the silencer (muffler). Disconnect the heat exchanger control boxes and their hoses and cables so that the control boxes can be removed. Remove the heater booster exhaust pipe.

6 On models fitted with automatic transmission, remove the dipstick as well as the filler tube. Disconnect the vacuum line from the intake manifolds balance pipe. It will also be necessary to remove the cover so that the three bolts securing the torque converter to the engine drive plate can be removed. Once the engine has been removed it is essential to fit a strap, or thick wire, across the converter housing to prevent the converter from falling out.

7 Remove the nuts from the upper engine securing bolts. Fit the transmission support VW.785 into the mountings of the diagonal arms so as to support the transmission. A jack may be used to support the transmission, but be sure to fit a pad of wood between jack and transmission to prevent damage to the castings or automatic transmission oil pan.

8 Support the engine on the trolley jack and adaptor. Remove the nuts from the lower engine supports and take out the four bolts securing the engine to the transmission. Draw the engine back until the transmission input shaft is clear of the clutch and then lower the engine so that it can be wheeled out from under the

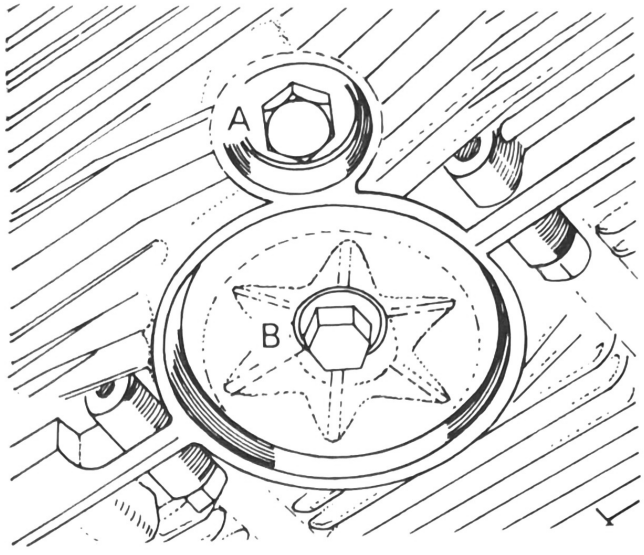


FIG 1 : 6 The engine drain plug and oil strainer

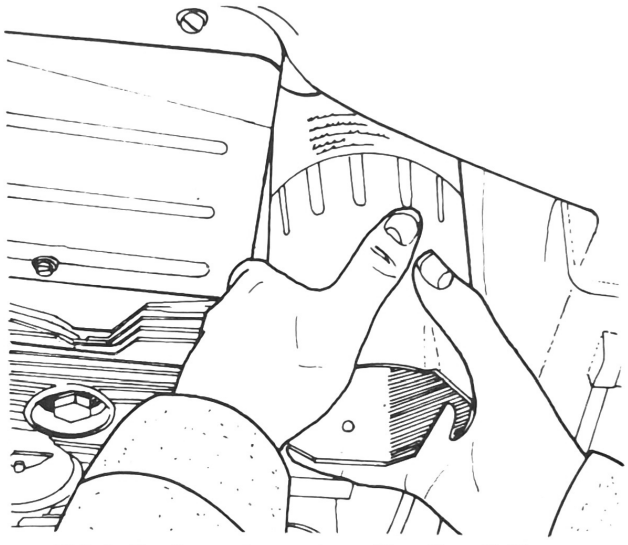


FIG 1 : 7 Removing or installing the oil filter

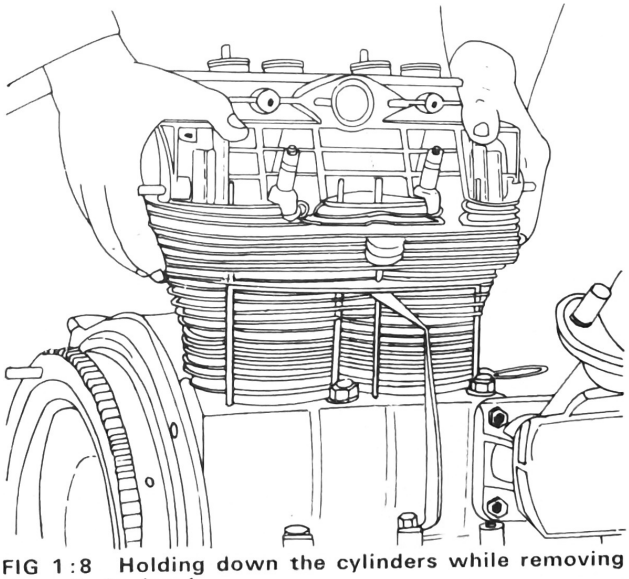


FIG 1 : 8 Holding down the cylinders while removing the cylinder head

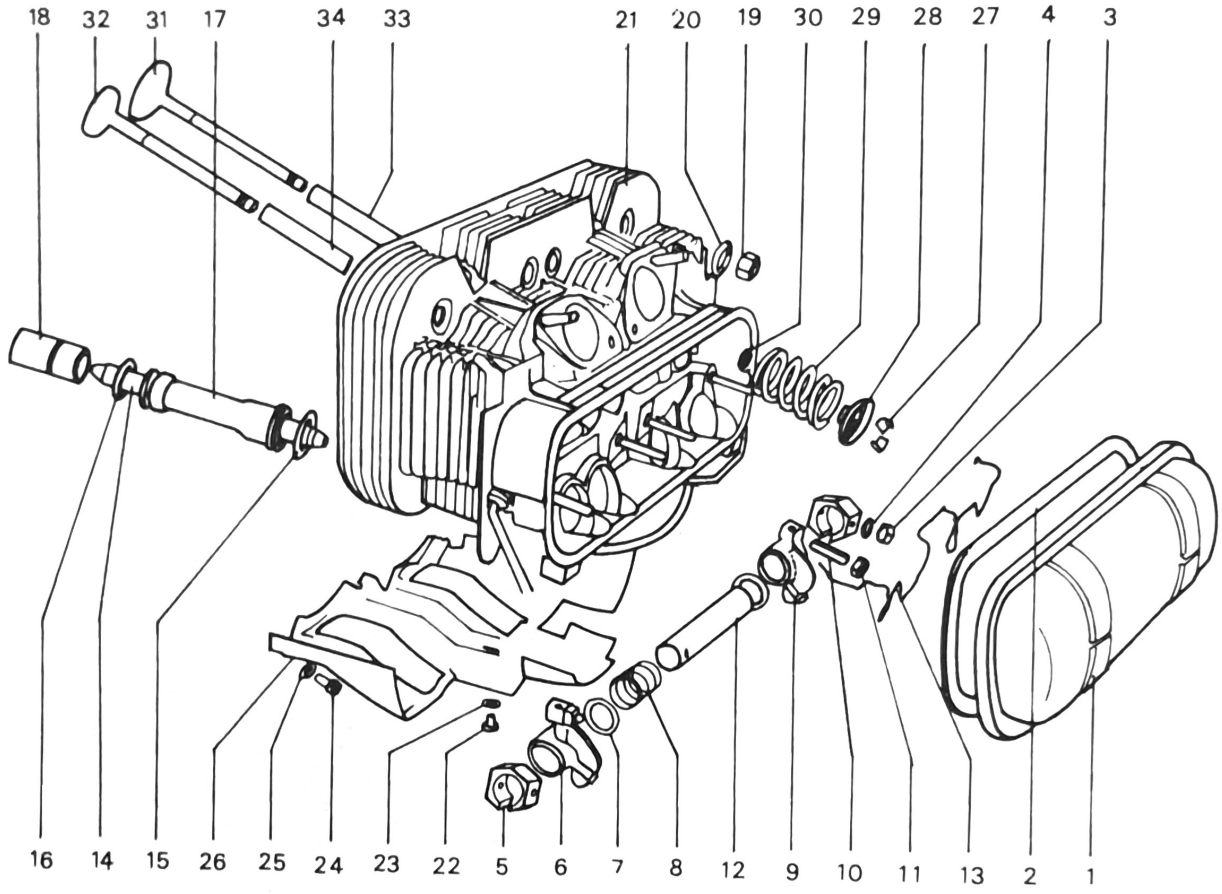


FIG 1:9 The cylinder head and its components

Key to Fig 1:9 1 Cylinder head cover 2 Cover gasket 3 Nut 4 Spring washer 5 Support 6 Exhaust valve rocker arm 7 Thrust washer 8 Spring 9 Inlet valve rocker arm 10 Valve adjusting screw 11 Locknut 12 Rocker shaft 13 Retaining wire for pushrod tubes 14 Pushrod 15 Seal 16 Seal 17 Pushrod tube 18 Tappet 19 Nut 20 Washer 21 Cylinder head 22 Cheese head screw 23 Washer 24 Cheese head screw 25 Washer 26 Deflector plate 27 Valve cotter halves 28 Spring cap 29 Valve spring 30 Oil deflector ring 31 Inlet valve 32 Exhaust valve 33 Inlet valve guide 34 Exhaust valve guide

vehicle. Do not forget to fit a retaining plate to hold the torque converter in place on automatic transmission models.

Installation:

The engine is installed in the reverse order of removal. Before installing the engine, visually check the clutch for damage (it may well be worth while removing the clutch so that it can be fully examined, to save work later). Check that the input shaft pilot bearing is in good condition. Check that the clutch release bearing is in good condition and not excessively worn.

Lightly lubricate the clutch release bearing guide with molybdenum disulphide paste. Check the splines of the input shaft of the transmission and rub some molybdenum disulphide powder onto them with a clean piece of rag. Apply a little lithium-based grease to the starter motor shaft.

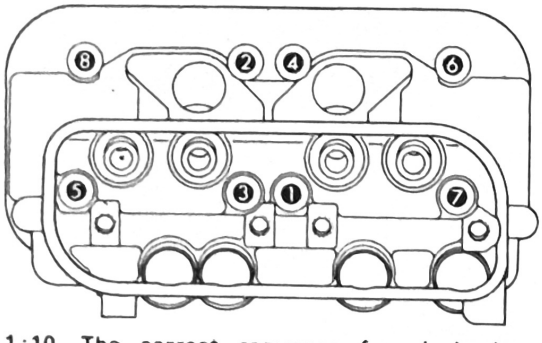


FIG 1:10 The correct sequence for slackening or finally tightening the cylinder head nuts

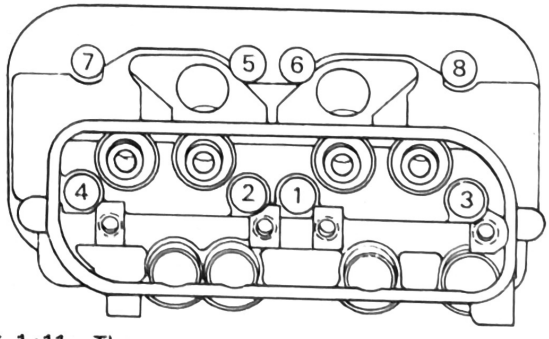


FIG 1:11 The correct sequence for the preliminary tightening of the cylinder head nuts

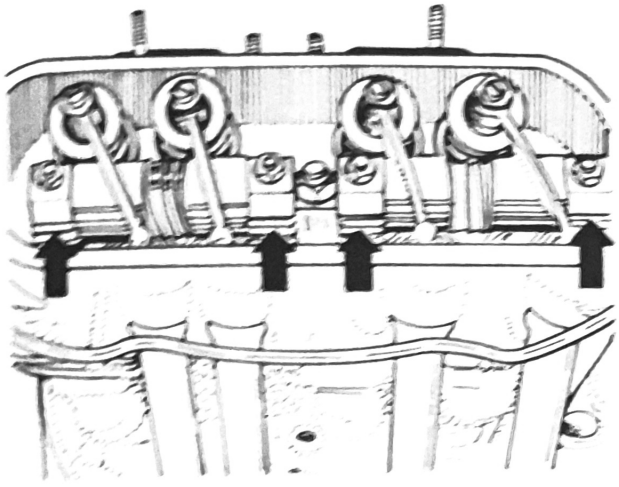


FIG 1:12 The correct installation of the rocker shaft clamps

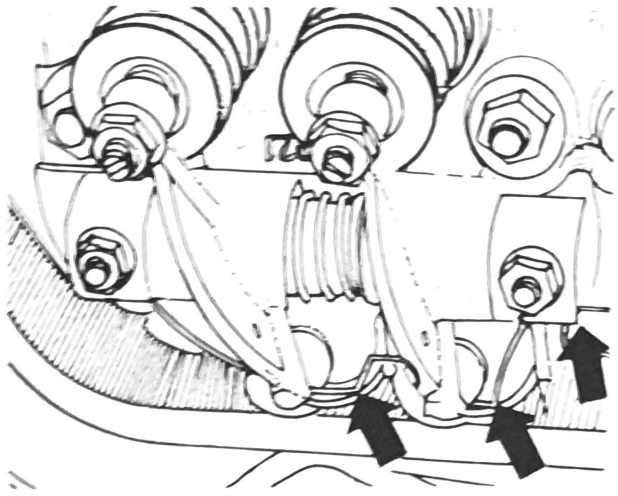


FIG 1:14 The wire clip for the pushrod tubes correctly engaged

Check the mating flanges of the engine and transmission for dirt or damage. Hard deposits should be softened with a suitable harsh solvent and then scraped off with a piece of perspex or hardwood. Light damage or nicks should be smoothed down with an oilstone, scraper or fine file.

When installing the engine, be sure not to allow it to hang on the transmission input shaft, otherwise the clutch will be damaged. Secure the engine fully into place before removing the supports. New self-locking nuts should be used to secure the engine carrier to the bonded mountings. Tighten them to a torque of 2.5 kg m (18 lb ft).

Slide in the drive shaft with the special wrench VW.796 in place, turning the shaft slightly as required. Engage the circlip by tightening the nut.

The remaining parts are then installed in the reverse order of removal. Set the throttle linkage in the full throttle position and make engine idling adjustments as required.

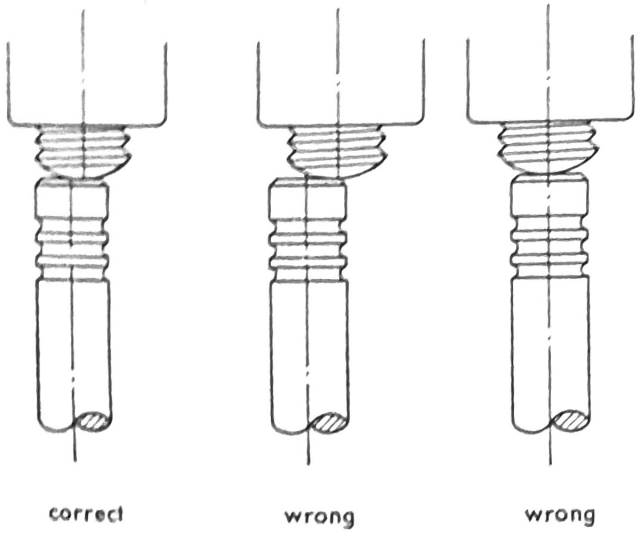


FIG 1:13 The correct and incorrect positioning of the rocker arms in relation to the valve stems

1:3 Oil and oil filter changes

When running-in a new or reconditioned engine, the oil and oil filter should be changed after the first 1000 kilometres (600 miles). After this first oil change, the oil should be changed at intervals of 5000 kilometres (3000 miles) and the filter element at intervals of 10,000 kilometres (6000 miles). This means that the oil filter is changed at every other oil change after the engine has been run in.

The drain plug for the engine is shown at **A** in **FIG 1:6**. Take the car for a short run to warm the oil and stir any loose dirt up into suspension. Remove the drain plug and allow the oil to drain out into a suitable container. While the oil is draining, remove the bolt **B** shown in the figure, take off the cover and withdraw the oil strainer. Wash the oil strainer in clean fuel and dry it with compressed air. Discard the old gaskets and assemble the strainer parts in the reverse order of removal. Tighten the bolt **B** to a torque of 1.0 to 1.3 kg m (7 to 9 lb ft). Refit the drain plug **A** using a new seal.

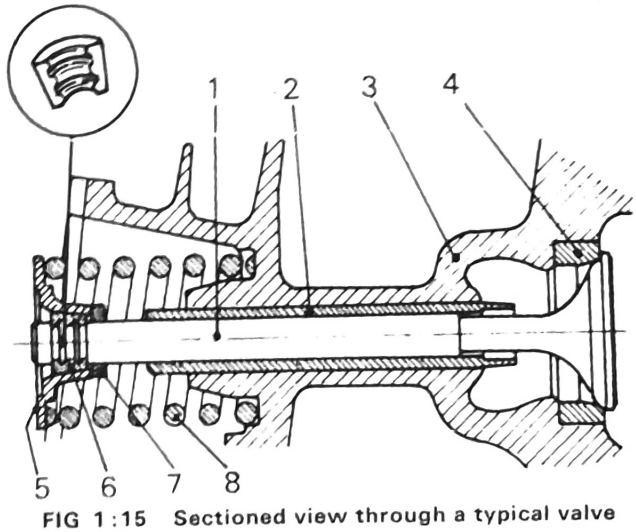


FIG 1:15 Sectioned view through a typical valve

Key to Fig 1:15 1 Valve 2 Valve guide 3 Cylinder head 4 Valve seat insert 5 Valve cap 6 Split collet (lock) 7 Oil seal 8 Valve spring

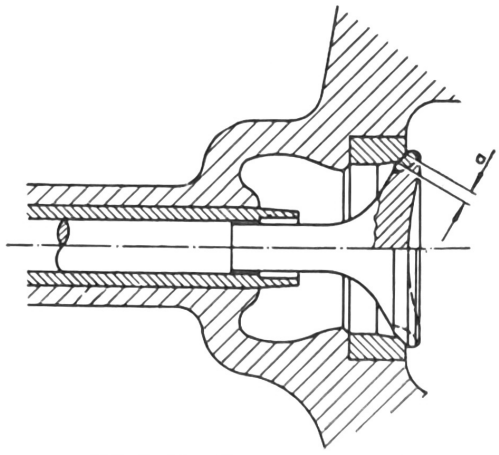


FIG 1:16 The valve seat width

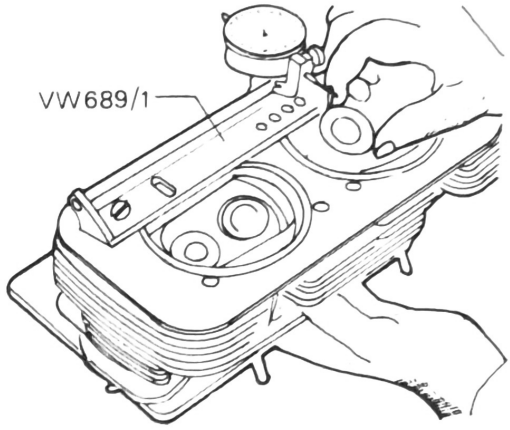


FIG 1:17 A method of checking the wear in the valve guides and valve stems

A special wrench or tool is required for removing the oil filter. One type of tool is shown in **FIG 1:7** and this has slots for a tommy bar so that the filter can be undone if it is stiff. Another type of tool is like a large C-spanner with teeth that fit into notches in the housing. It is just possible to use a conventional strap spanner to turn the filter. Unscrew the old element and discard it, without attempting to clean it in any way. Check the gasket on the new element and smear it lightly with engine oil. Fit the new element by hand until the gasket can be felt to contact the engine, then tighten the element by a further half turn.

Filling:

The engine dipstick has two marks on it, indicating the maximum and minimum levels. The minimum quantity of oil should be 2½ Litres (4½ Imp pints, 5¼ US pints).

For an oil change only, 3 Litres (5.25 Imp pints, 6.3 US pints) of oil will be required but for an oil and filter change 3.5 Litres (6.1 Imp pints, 7.3 US pints) of oil are needed.

Fill the engine with just less than the correct amount of oil and start it up. Check for oil leaks around the filter or

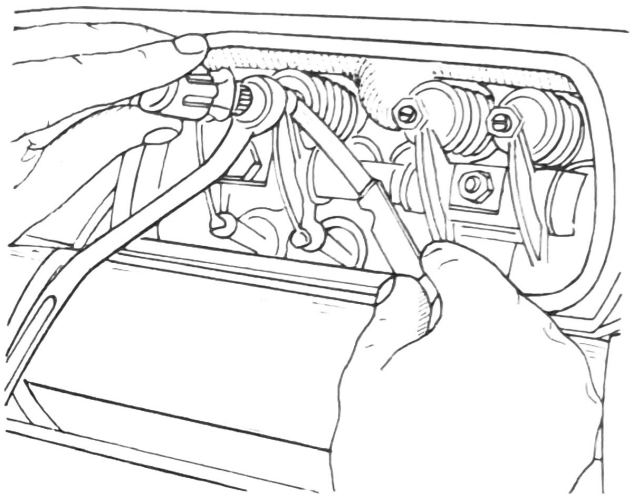


FIG 1:18 Setting the valve clearances

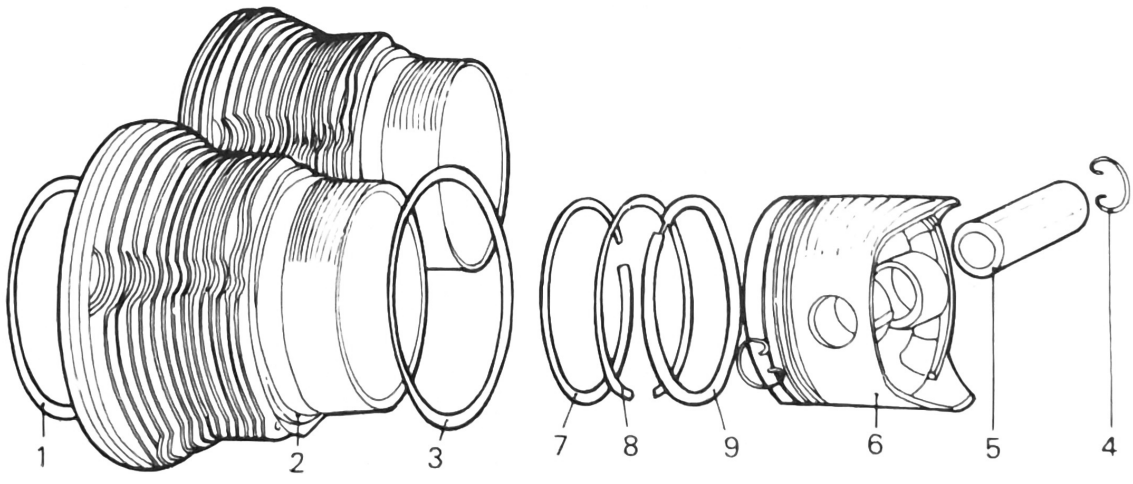


FIG 1:19 The pistons and cylinders

Key to Fig 1:19 1 Sealing ring 2 Cylinder 3 Sealing ring 4 Circlip 5 Piston pin 6 Piston 7 Upper compression ring 8 Lower compression ring 9 Oil scraper ring

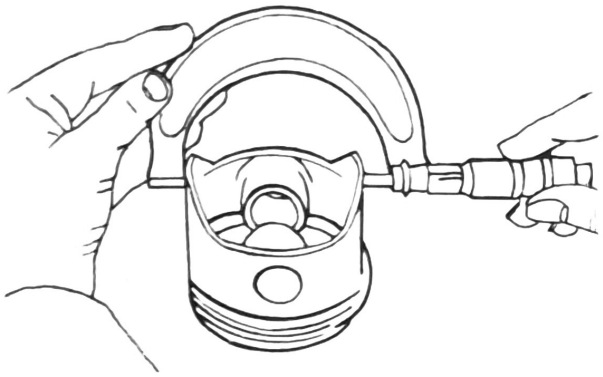


FIG 1:20 Measuring the piston diameter

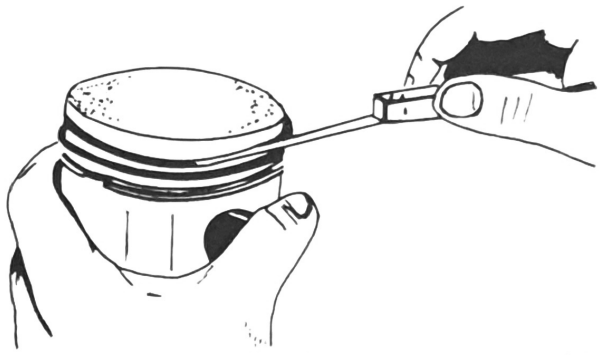


FIG 1:22 Checking the side clearance of the piston rings in the piston

strainer. Drive the car onto level ground and stop the engine. Leave for five minutes to allow the oil level to settle and then top up to the full mark on the dipstick. Do not overfill the engine as this can lead to oil leaking past oil seals, excessive consumption, and frothing of the oil by the big-end bearings thrashing in it.

In use, topping up to the upper mark is only essential when the level has fallen to the lower mark on the dipstick.

Extreme condition:

If the oil remains cold there is little chance of contaminants and water (products of combustion) evaporating from the oil, which will quickly become too dirty to use. If the car is only used for city driving or short distances in wintry conditions the oil should be changed at intervals of 2500 kilometres (1500 miles). If the car is used in Arctic conditions with the average temperature around —25°C (—15°F) the oil should be changed at intervals of 1250 kilometres (750 miles).

In temperate climates any good grade of HD SAE.30 oil may be used. In normal winter conditions SAE.20W/20 oil may be used.

For average temperatures between 5°C (40°F) and —30°C (—20°F) an SAE.10 oil should be used. For average temperatures below —10°C (25°F) an SAE.5 oil should be used. Note that there is an overlap for the different grades of oil and that the figures are a guide and not mandatory.

The use of a thinner oil as the temperature drops will ensure easier starting.

1:4 Torque wrench settings:

A torque wrench is nearly as essential a tool for working on the engine and transmission as a set of spanners. Light-alloy is used extensively in the construction of the engine and that 'extra pull on the spanner for luck' can easily strip threads or damage components. Main torque wrench settings are given throughout in the relevant sections and a consolidated list is also given in the **Appendix.**

Stripped threads can be repaired using Heli-coil inserts. The task is best left to a service garage but basically the stripped thread is tapped out with the appropriate tap for the size. The Heli-coil insert is then screwed into place down these tapped threads, using the special tool for the purpose, and the tang broken off. The attachment bolt will then run up and down using the Heli-coil insert as the threads.

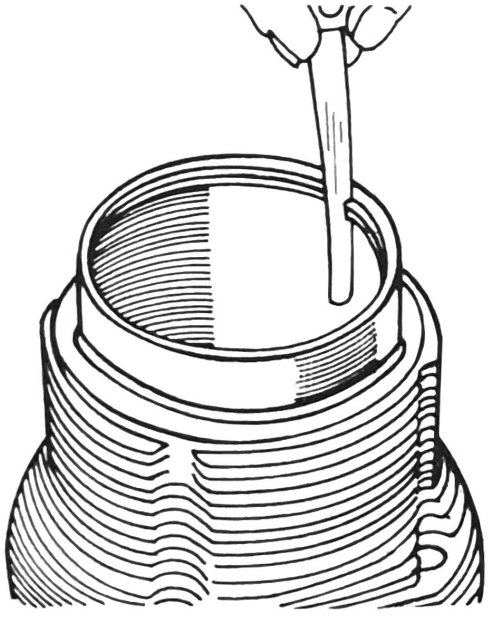


FIG 1:21 Checking the fitted gap of the piston rings

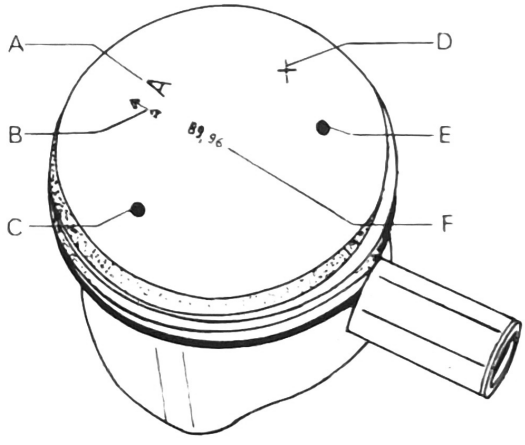


FIG 1:23 Typical piston crown markings

Key to Fig 1:23 **A** Part number and identification mark **B** Arrow or word VORN **C** Blue, Pink or Green paint mark showing grade **D** Weight grading mark **E** Paint mark showing weight grading (Brown = —, Grey = +) **F** Piston size in millimetres

1 :5 The cylinder heads and valve gear

The cylinder heads are made of light-alloy, so great care must be taken not to damage them or to score the joint faces. The nuts and studs securing the cylinder heads also keep the cylinder barrels in place so care must be taken not to allow the cylinders to move once the head is off. One method of holding down the cylinders is shown in **FIG 1 :8**, though thick wire may be used in a similar manner. Take care not to break off or damage the cooling fins on the cylinders. Typical cylinder head components are shown in **FIG 1 :9**.

Removal:

The cylinder heads should not be removed when the engine is hot as this can be a cause of distortion.

1 With the manifolds and deflector plates removed, pull down the spring that secures the rocker cover in place and remove the cover with its gasket. Evenly slacken and then remove the nuts securing the rocker shaft assembly to the head. Slide off the rocker shaft assembly. If both cylinder heads are being removed, mark the rocker assemblies so that they cannot become interchanged.
2 Free the wire clips securing the pushrod tubes. Progressively and evenly slacken the cylinder head attachment nuts in the order shown in **FIG 1 :10**. Make sure that both (or all four) cylinders are held down by some form of clamp (see **FIG 1 :8**).
3 Carefully pull off the cylinder head by hand, making sure that it is kept square. If the head sticks assist it with light blows from a hide-faced or rubber mallet. Take great care to hit squarely and not to hit at one point only but work evenly around the base. The fins are of light-alloy and can easily be damaged. Do not crank the engine as there is a danger of the cylinders moving or the head tilting.
4 Remove the pushrods, their tubes, and related parts. Discard all old gaskets and seals. It is essential that pushrods are stored in the correct order as they must be installed back into their original positions.

Installation:

1 Check all the parts and service the components. Make sure that all parts are scrupulously clean before assembly and use all new seals and gaskets. Lubricate bearing surfaces liberally with clean engine oil or graphited oil.
2 Fit the pushrods and their tubes, noting that care will be needed to guide these back into position as the head is installed. Take great care not to damage the seals on the pushrod tubes.
3 Fit the cylinder head back into place and secure it with all the nuts fingertight. Progressively tighten the cylinder head nuts to a torque load of 1.1 kg m (7 lb ft) in the order shown in **FIG 1 :11**, making sure that the head is seating correctly and not cocked. When the preliminary tightening has been completed tighten the bolts to the correct final torque of 3.2 kg m (23 lb ft) in the order shown in **FIG 1 :10**.
4 Install the rocker arm assembly back into place, tightening the nuts to 1.4 kg m (10 lb ft) making sure that the slots in the shaft clamps face in the original direction. Take care to make sure that the pushrods are correctly seated in the tappets and rocker arms during this operation. Typical correct positioning of the clamps is shown in **FIG 1 :12**. The rocker assembly should be set so that the ends of the rocker arms are very slightly offset in relation to the ends of the valve stems, so that they impart a slight rotation to valves as they operate. A typical set-up is shown in **FIG 1 :13**.
5 The wire clips for retaining the pushrod tubes are fitted as shown in **FIG 1 :14**, so that they are in the slots of the rocker shaft bearings and enter the bottom edge of the pushrod tubes.
6 Set the valve clearances as described in the next section and refit the remainder of the parts in the reverse order of removal.

Decarbonizing:

Sharp metal tools must not be used for removing carbon or deposits. Scrapers should be made up from hardwood, perspex or solder. Shape the end to a suitable chisel point. Similarly wire brushes, hand or rotary, must not be used. A special rotary wire brush, with wire enclosed at both ends, is made for cleaning valve guides and it is permissible to use this.

Leave the valves fitted while cleaning the combustion chambers as the valves will protect the head seats. Scrape out carbon and deposits, taking great care not to damage or score the cylinder head seating faces (including those for the manifolds). If desired, a light polish can be given using worn emerycloth dipped in paraffin (kerosene). Once the chambers have been cleaned, the the valves can be removed and the ports cleaned out in a similar manner, taking great care not to damage the valve guides or head seats. If the special rotary wire brushes are not available, clean the valve guides by pulling strips of cloth soaked in solvent through them. Thoroughly clean the cylinder head with a suitable solvent after decarbonizing.

Make sure that the cylinders are held down firmly in place and carefully crank the engine until the piston is near TDC. Scrape off deposits from the crown in a manner similar to that for cleaning the combustion chambers. The light polish with worn emerycloth must only be carried out on the piston crown if the piston is removed from the engine, otherwise abrasive particles cannot be satisfactorily removed.

Examine the fins on the cylinder head for cracks or damage. Nicks or breaks should be blended in smoothly by the use of a file. If an excessive number of fins are damaged, a reconditioned cylinder head should be fitted.

Valve removal:

A conventional valve spring compressor should be used for removing the valves and their associated parts. A typical sectioned valve and its related parts are shown in **FIG 1 :15**. Fit the compressor so that its end holds the head of the valve and press down so that valve cap 5 is pressed down the stem and the spring 8 compressed. If the cap sticks, give it a light tap with a hammer to free it. Lift out the spring collets using tweezers, long-nosed pliers, or a piece of magnetic rod. Release the tool slowly and remove it. Remove the valve cap, spring, and seal. Discard the oil seals, fitting new ones on reassembly. Slide the valve out through the combustion chamber.

Check and clean the parts then reassemble them in the reverse order of dismantling. Lubricate the valve stem liberally with clean oil. Once the parts have been fitted, give the end of the valve stem a sharp blow with a hammer to make sure that the split collets are fully seated.

Valves:

Remove deposits from the valve using a scraper or rotary wire brush. Take care not to damage the seating face of the ground portion of the stem.

Check the head of the valve for burning or excessive pitting of the seat. There must be at least .8 mm ($\frac{1}{32}$ inch) of head material left above the seating face and if there is less than this minimum, or the seat makes a sharp edge, the valve must be renewed.

Check the stem of the valve for scores, wear or bends. Use a steel straightedge to check the straightness of the stem. Light damage or wear on the end of the stem can be trued up by grinding or using an oilstone. Discard badly pitted, burnt valves or any which have defective stems.

Valve springs:

These should be checked by applying load to them and noting their length. If they are satisfactory a load of 81 to 93 kg (178 to 205 lb) will be required to compress them to a length of 29.9 mm (1.18 inch).

If a special rig for testing the springs cannot be borrowed or made up, obtain one new valve spring. Mount each old spring in turn end on to the new one and compress the pair between the jaws of a vice. If the old spring is weak, it will be appreciably shorter than the new one. If weak valve springs are found, the complete set should be renewed.

Pushrods:

Check the pushrods for bend, renewing any that are bent without attempting to straighten them. The pushrods can either be rolled along a true surface or they can be laid on V-blocks and rotated while using a dial indicator gauge to check for excessive runout.

Flush through the pushrods with paraffin, or suitable solvent, followed by compressed air.

Grinding valve seats:

If garage cutting or grinding equipment is used to cut the seats, note that the inlet valve angle is 30 deg. while that for the exhaust valves is 45 deg.

Check all seats for excessive pitting. Those which are badly pitted should be recut using garage equipment as the use of grinding paste will remove excessive metal from the mating seat.

Slide the valve back into its guide and smear a little grinding paste around the seat. Use medium-grade initially unless the seats are in good condition, in which case only fine-grade paste need be used.

Press the valve down into its seat using a suction cup tool and grind with a semi-rotary motion, spinning the handle of the tool between the palms of the hands. Regularly withdraw the valve partially, turn it through a quarter-turn and then press it back to carry on grinding. This ensures that concentric scores are not allowed to build up. Carry on with medium-grade paste until only very shallow pits are left. Wipe away all traces of paste and repeat the process using fine-grade paste until both seats are matt-grey with no pits or scores. Wash the head and valve thoroughly to remove all traces of abrasive particles.

Check the seat width, shown in **FIG 1 :16**. For exhaust valves the seat width in the head should be 2.0 to 2.5 mm (.078 to .098 inch) and that for the intake valves 1.8 to 2.2 mm (.070 to .086 inch). If the seats are too wide they should be narrowed using 75 deg and 15 deg. cutters. The 15 deg. cutter will lower the seat width into the head while the 75 deg. cutter will narrow the seat width out of the head. Lightly smear Prussian Blue on the seat, press the valve down and rotate the valve so that the area of contact will be shown on the valve. Use the cutters to set the cylinder head seat to the correct width and so that it meets the valve sealing face centrally. The Prussian Blue will also show that the valve is seating fully around its circumference.

Valve seats and valve guides:

These are a shrink fit into the light-alloy of the head and if they are defective a factory reconditioned cylinder head must be fitted. The owner cannot install new guides or valve seats.

Check the valve seats for cracks, or cracking of the light-alloy around them. If valve grinding has increased the diameter of the chamfer until it is very close to the diameter of the insert then a reconditioned cylinder head must be installed.

A typical method of checking the wear in the valve guides is shown in **FIG 1 :17**. Use a new valve and fit it so that its stem is flush with the end of the guide. Rock the head of the valve backwards and forwards, noting the play on the dial indicator gauge. Excessive play denotes excessive wear and this in turn will lead to high oil consumption.

1 :6 Setting the valve clearances

This should be carried out after cylinder head remo. and installation, or if the valve train sounds noisy.

Remove sufficient cowling, free the clip, and take off the rocker cover on each cylinder head.

The engine must be cold when setting the valve clearances. The method of adjustment is shown in **FIG 1 :18**. A feeler gauge of the correct thickness is inserted between the end of the valve stem and the adjusting screw on the rocker arm. Crank the engine until a pair of valves is fully closed. Slacken the locknuts on the adjusters with a ring spanner and slide the feeler gauge into place. Use a screwdriver to turn the adjuster until sliding drag is felt on the feeler gauges as it is moved. Hold the adjuster with the screwdriver and tighten the locknut. Check that the adjustment has not altered. Adjust the other valve on the cylinder in a similar manner.

Crank the engine through 180 deg. and the valves of the cylinder next in the firing order will be fully closed. Adjust the clearance and then repeat the procedure on the remaining two cylinders.

Refit the rocker covers, using new gaskets if required, and install cowling parts removed.

A special tool is made to assist in setting the clearances but this is basically a spanner and screwdriver combined and saves juggling with the various tools to try and keep them all in place.

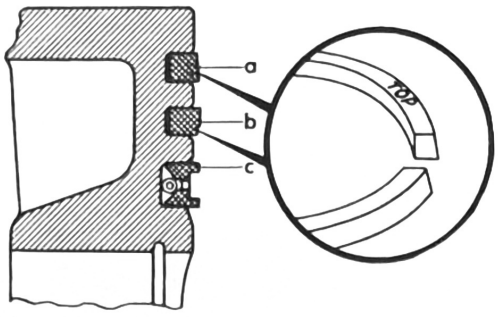


FIG 1:24 The piston rings installed

Key to Fig 1:24
a Upper compression ring
b Lower compression ring
c Oil scraper ring

Damaged valve stem ends, adjusting screws, or rocker arms will make it difficult to set the clearance accurately. If the end of a valve stem has spread at all, be sure to use an oilstone to remove any burrs before sliding the valve out of its guide otherwise the guide will become scored.

1:7 Cylinders and piston

The components are shown in **FIG 1:19**.

Removal:

It is possible to remove a cylinder head and both its cylinders as an assembly after the cylinder head nuts have been removed. This is not recommended for the average owner because of the danger of tilting a cylinder and jamming the piston, and the danger of the pistons and connecting rods dropping sharply as they come free from the bore.

Remove the cylinder head as described in **Section 1:5**. It is most advisable to mark the piston crowns, cylinders and equivalent mounting points on the crankcase with a code of different spots of coloured paint, as pistons and cylinders must not be interchanged in position once they are bedded-in.

Carefully pull each cylinder in turn away from the crankcase so that the piston slides out of it and the attachment studs do not catch in the cooling fins. As the piston starts to come free, support the connecting rod so that there is no danger of the piston and rod assembly falling and damaging the crankcase. Once the cylinders have been removed, take great care when cranking the engine as there is a danger of the connecting rods thrashing up and down, to the detriment of the crankcase, or the pistons catching on the studs.

Use circlip pliers to remove the circlips securing the gudgeon pins in the pistons. Try pressing the gudgeon pin out by hand pressure so that the piston can be freed from the connecting rod. If the gudgeon pin is stiff to press out, wrap the piston in rags and pour boiling water over it to heat the piston. Use sheets of tin or equivalent to prevent the water running into the engine. Once the piston has reached a temperature of approximately 80°C the gudgeon pin should slide out easily with hand pressure. It is advisable to discard the retaining circlips and install new ones on reassembly.

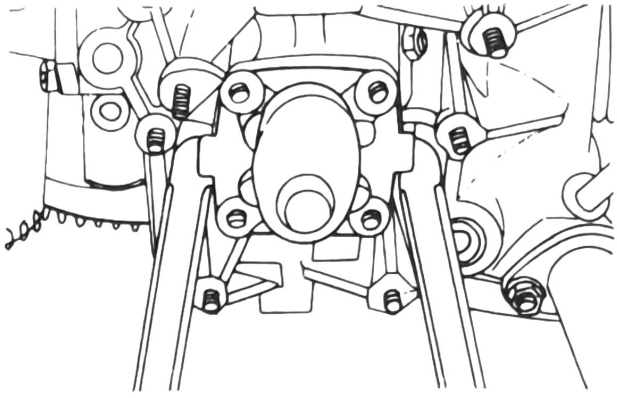


FIG 1:25 Typical method of removing the oil pump

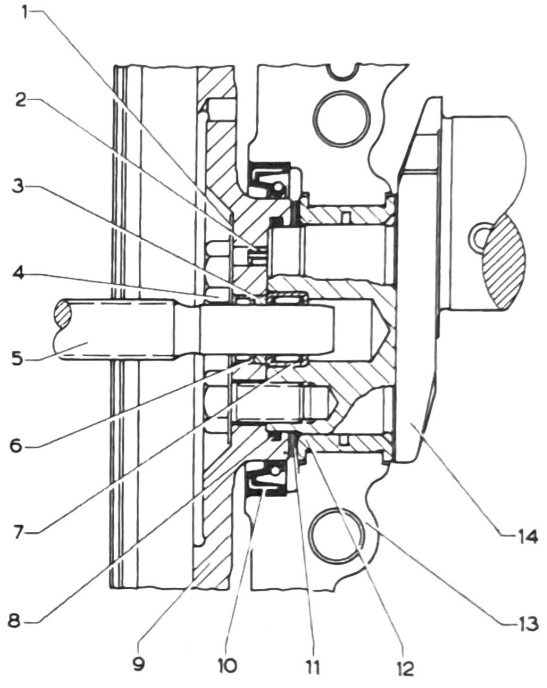


FIG 1:26 Sectioned view of the flywheel attachment and rear oil seal

Key to Fig 1:26 1 Washer 2 Split sleeve 3 Felt ring 4 Screw 5 Drive shaft 6 Spacer 7 Needle bearing 8 Sealing ring (rubber) 9 Flywheel 10 Oil seal 11 Shim 12 No. 1 crankshaft bearing 13 Crankcase 14 Crankshaft

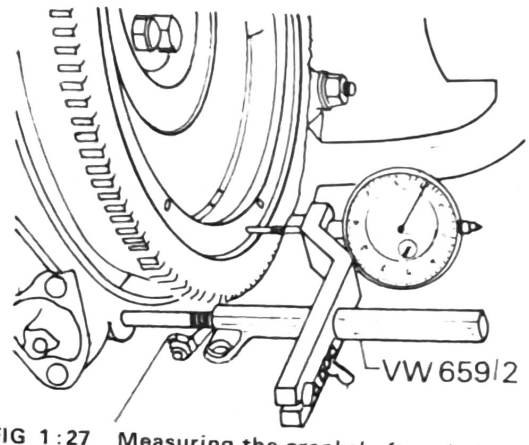


FIG 1:27 Measuring the crankshaft end play

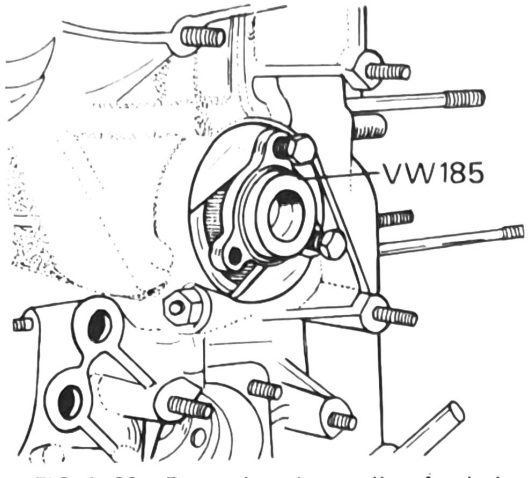


FIG 1:28 Removing the cooling fan hub

Cylinder bores:

These should be checked whenever the cylinder head is removed. A good guide to the amount of wear is given by judging the thickness of the unworn ridge around the top of the bore.

For accurate checks of bore wear and piston to bore clearance special gauges are required. The bore should be measured at several points to determine the ovality, taper, and wear. Measure with, and at right angles to, the thrust axis noting that the maximum wear will take place approximately 25 mm (1 inch) from the top of the bore. Measure the skirt of the piston with a micrometer gauge, as shown in **FIG 1:20**, so that the skirt to bore clearance can be calculated. Reboring and fitting an oversized piston or fitting new piston and cylinder should be carried out if the running clearance exceeds .20 mm (.008 inch).

The oil consumption of the engine will generally give a good guide to the state of the bore. New parts should be fitted when the oil consumption exceeds 1 Litre in 1000 kilometres (approximately 3 pints per 1000 miles). Check that high oil consumption is not due to external leaks or worn valve guides.

If the oil consumption is fairly high but not sufficient to warrant fitting new parts, new rings can be fitted to the pistons. Before fitting new rings, have the unworn ridge around the tops of the bores removed and the whole bore surface lightly honed. The ridge will have worn in with the old ring and the new ring, being unworn, will therefore hit the ridge and break up. Light honing or scuffing of the bore breaks the glaze and allows the new rings to bed-in better.

If a bore is found to be scored, the cylinder must be renewed and similarly defective pistons must also be renewed.

Piston rings:

Special ring clamps are made for removing and installing the rings on the piston. The tool gently parts the ends of the ring so that it can be lifted up over the piston crown. Failing the special tool, the rings can still be removed and installed using three steel shims (such as discarded feeler gauges). Carefully lift the end of the top ring out of its groove and slide one shim under it. Work the shim around under the ring, pressing the ring onto the piston land above it as the ring frees but taking care not to use force. Once all the ring is on the land, slide the other two

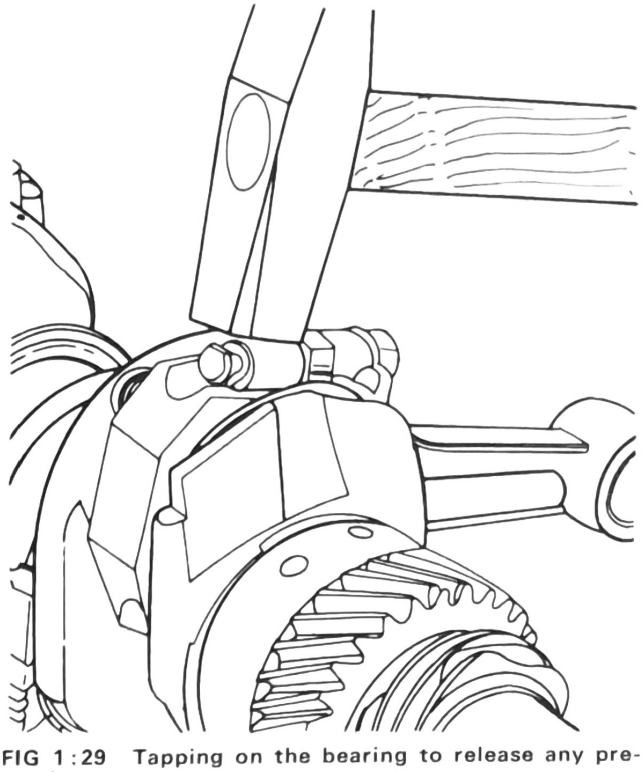


FIG 1:29 Tapping on the bearing to release any pre-tension

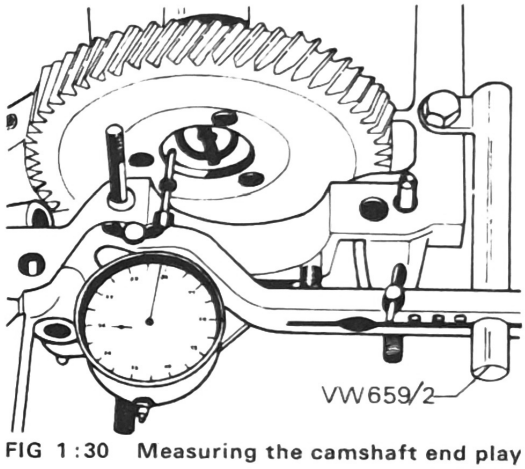


FIG 1:30 Measuring the camshaft end play

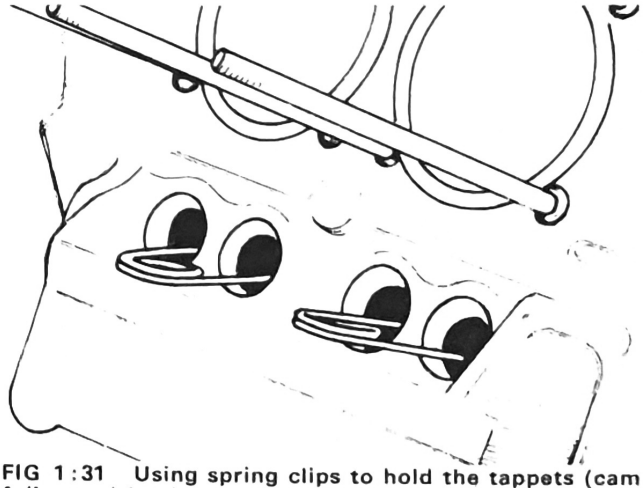


FIG 1:31 Using spring clips to hold the tappets (cam followers) in place

shims under the ring so that all three are equally spaced, and slide the ring up and off the piston using the shims to protect the piston. Gently parting the ends of the ring with the thumb nails will help, but take care not to score the back of the piston with the ring. Remove the remaining rings in a similar manner.

Before installing new piston rings, check their fitted gap. Spring the ring into the bottom of the cylinder and push it slightly down with a piston so that the ring is square in the bore. Measure the gap between the ends of the ring with feeler gauges, as shown in **FIG 1 : 21**. If the gap is incorrect, either renew the ring or carefully file the ends to bring the gap within limits.

When the rings have been installed in the piston, check the side clearance with feeler gauges, as shown in **FIG 1 : 22**. It is possible to fit the outer edge of the ring into the groove, and check the side clearance, without actually installing the rings. If the clearance is excessive, try using a new ring and if the clearance is still excessive a new piston must be fitted.

Pistons:

Remove the piston rings before cleaning the pistons. The crowns can be lightly polished with worn emerycloth dipped in kerosene after deposits have been removed with a soft scraper. Clean the ring grooves with a piece of broken piston ring. Take great care to remove only carbon and dirt from the ring grooves as if metal is removed the oil consumption will be increased. Clean out the return holes behind the oil control ring with a piece of blunt-ended wire.

Lacquering on the sides of the piston should only be removed using a suitable harsh solvent to soften the deposit and then scrubbing with a proprietary non-metallic pot scourer. Do not use abrasives on the piston sides.

Check the piston skirt for uneven wear pattern or polished areas which indicate a distorted connecting rod.

When cleaning the pistons, take care not to interchange them as the identification paint marks may easily be washed off.

The selection of the correct grade and weight of piston is best left to a VW dealer. New pistons will have the marks as shown in **FIG 1 : 23** on their crowns. The main mark to note is the arrow or word 'VORN' and the piston must be installed so that this mark faces the flywheel end of the engine. The gudgeon pins are slightly offset in the pistons, to prevent piston slap, and it is for this reason that the pistons must be installed in the correct direction.

Connecting rods:

Thoroughly clean the connecting rods and check them for obvious damage. If it is suspected that a connecting rod is bent or twisted, because of the wear pattern on the piston or crankpin, the rod should be checked on special jigs. A slight amount of distortion can be straightened under a press or using a special jig.

Because the gudgeon pin can be pressed through the small-end bush or piston while the parts are cold this does not indicate excessive wear. If the piston bores are worn a new piston must be fitted. Renewable bushes are fitted to the small-ends of the connecting rods. A special jig is required to renew these bushes so again the work should be left to an agent.

Cooling fins:

Check the cooling fins on the cylinders for damage. Distorted fins should be straightened as much as possible without exerting sufficient force to snap them. Nicks or broken portions should be blended in smoothly using a file or small rotary grindstone.

Installation:

Thoroughly clean the mating surfaces of the cylinders and crankcase, as well as those of cylinders and head. Soften any old jointing compound using carbon tetrachloride or trichlorethylene and then scrape off with a tool made from hardwood or perspex. Under no circumstances clean the light-alloy surfaces with a wire brush or hard metal scraper.

Wash the parts in suitable solvent to remove any dirt. The cylinders should have been cleaned on removal, but to protect the bores against corrosion they should be smeared with grease. It is this grease and dirt which must now be removed.

Install the piston rings in the reverse order of removal. The dimensions are given in **Technical Data** at the end of the manual. The upper compression ring is tapered and the lower compression ring stepped. Both of these rings must be fitted so that the marking 'TOP' on them faces towards the crown of the piston, as shown in **FIG 1 : 24**.

Fit the circlips on the flywheel side of Nos. 1 and 2 pistons and on the fan side of Nos. 3 and 4 pistons. Make sure that the circlips are fully seated in their grooves. Heat the pistons in boiling water. Take out each piston in turn, holding it with rags, and fit it to its correct connecting rod. Make sure that the arrow or word 'VORN' points towards the flywheel for all pistons. Press the gudgeon pin in fully by hand so that the piston is fitted to the connecting rod. Install the other circlip to secure the gudgeon pin, making sure that this too is fully in its recess.

Lightly oil the piston skirt and piston rings. Turn the oil control ring so that its gap is uppermost and turn the other two rings so that their gaps are evenly spaced at 120 deg. Fit a ring clamp so that the rings are compressed into their grooves. If the correct VW tool, or a proprietary equivalent is not available a large worm-driven hose clip may be used instead, but more care must then be taken.

Fit a new sealing ring and guide the cylinder onto its studs, aligning the previously made paint marks, and carefully press it down to the crankcase. Guide the piston into the bore and allow the ring clamp to slide off the rings as they enter the bore. Do not allow the rings to escape from the clamp before they are in the bore and do not use force. The whole operation is fairly tricky and it is advisable to have an assistant to support the parts and check that studs are not catching in fins.

Once a pair of cylinders is in place, install their cylinder head.

1 : 8 The lubrication system

A schematic layout of the lubrication system is shown in **FIG 1 : 3** and the general operation is described in **Section 1 : 1**. Draining and changing of the engine oil as well as the oil filter element is described in **Section 1 : 2**.

If the oil cooler is found to be leaking, check the main

pressure relief valve. If the piston of the main relief valve sticks closed, excessively high oil pressure will be built up and may cause damage to the oil cooler.

Oil cooler:

Free the attachments and remove the oil cooler. Discard the old seals, installing new ones on reassembly. Blank off the connections to prevent dirt from entering the engine or oil cooler.

Wash down the outside of the oil cooler using any suitable cleansing solvent. Blow through between the fins with compressed air to make sure that they are absolutely clear and clean. Once the exterior is clean, flush through the interior with clean solvent (such as fuel or trichlorethylene) and then blow through with dry compressed air.

A rough check for leaks can be made by partially filling the oil cooler with fuel or solvent (after the exterior is dry), blanking the inlet and outlet, and examining the outside surface.

Normally a leaking oil cooler should be exchanged and not repaired by the owner. If the leak is small and fairly accessible, and the metal can be thoroughly cleaned and degreased, the area can be covered with a catalytic type of epoxy glue, which will withstand the heat and pressure as well as being very hard when set.

If there is any doubt as to the condition of the oil cooler it should be pressure-tested to 6 kg/sq cm (85 lb/sq inch). Do not use compressed air for testing because if the unit ruptures it may do so explosively. Fill the unit with fluid and test it hydraulically, as any failure will allow an immediate drop in pressure with no danger of further rupturing.

Relief valves

Remove the plug and withdraw the spring and plunger. If the plunger sticks in position, thread in a suitable tap and use the tap to withdraw the plunger.

Sticking of the upper relief valve plunger in the out position will cause all the oil to flow through the oil cooler and give a prolonged warm-up period, while sticking in the inner position may cause overheating.

Sticking of the lower relief valve plunger in the closed position will raise the oil pressure and may cause the oil cooler to fail, while sticking in the open position will cause a drop in oil pressure.

The plunger should be discarded if it is scored or worn. Light damage or high spots may be smoothed down with Crocus paper to make sure that the plunger slides freely in its bore.

Check the springs for weakening or corrosion and renew them if they are defective. The data for the springs is given in **Technical Data**.

Oil pump:

The cooling fan and ducts must be removed before the oil pump is accessible. Take off the four nuts attaching the oil pump and then withdraw it with the aid of two levers, used in a similar manner to the one shown in **FIG 1:25**. Removal of the cover from the pump is best carried out by using the special tool VW.803.

The pump should give long service without appreciable wear as it carries the full oil flow through the engine. The most likely cause of oil pump wear is failing to change the engine oil at the stipulated intervals so that dirt particles are drawn through.

Check the gears for undue wear marks on their teeth faces and check that the driven gear revolves freely on its pin. Check that the pin is securely in place.

Check the housing and cover for wear or scores. Light scoring on the coverplate may be lapped down on fine-grade grinding paste spread onto plate glass, but if the wear or scoring is excessive a new cover or new pump should be fitted, as a worn pump can be one of the causes of low oil pressure.

After washing the parts and examining them, liberally oil the gears and fit them back into the pump body. Lightly oil the sealing ring and refit it together with the cover. Check that the gears rotate freely. Set the tab on the pump shaft so that it aligns with the slot in the end of the camshaft and push the pump back into position. Slowly crank the engine through two complete revolutions so as to centralize the pump and then tighten the attachment nuts.

1:9 Clutch and flywheel

Full details of the clutch, its maintenance, and servicing are given in **Chapter 5**. This section deals only with the removal and installation of the clutch.

The engine must be removed from the car before the clutch and flywheel are accessible.

Clutch:

If the clutch is to be used again, make light aligning marks across clutch cover and flywheel so that the balance will not be lost when the clutch is installed.

Slacken the six bolts securing the cover to the flywheel, one or two turns at a time and in a diagonal sequence. It is essential that the bolts are slackened in this sequence otherwise the pressure of the clutch spring may distort the cover. Once all the bolts are removed, lift off the cover assembly and carefully collect the driven plate (without allowing it to drop). Do not handle the clutch driven plate with dirty or greasy hands and keep oil or grease away from the linings.

Check the clutch for wear or defects (see **Chapter 5**). Fit the driven plate back into place, holding it there with a special mandrel. The mandrel fits accurately through the hub of the driven plate and has a spigot which fits into the needle roller bearing in the end of the crankshaft. It is essential that this mandrel is used as it centralizes the driven plate, allowing the transmission input shaft to be inserted. Fit the cover back into place, aligning the previously make marks. Progressively tighten the attachment bolts in a diagonal sequence to a torque of 2.5 kg m (18 lb ft).

Flywheel:

A sectioned view of the flywheel attachment and crankshaft rear oil seal is shown in **FIG 1:26**.

The flywheel starter ring gear is integral with the flywheel and if the teeth are broken or badly worn, a new flywheel must be fitted. Slight damage to the teeth can be removed by having a maximum of 2.0 mm (.08 inch) skimmed off the clutch side of the teeth but the edges should then be lightly chamfered to give a lead-in for the starter motor pinion. Small burrs or light damage should be smoothed down with a file and oilstone.

If the clutch face of the flywheel is scored or burnt, it may be machined down to provide a flat surface again, though if the damage is deep a new flywheel must be fitted.

The shims 11 fitted between the flywheel and crankshaft control the end play of the crankshaft. The method of checking the crankshaft end play is shown in **FIG 1 : 27**. When making adjustments, such as after reassembling the engine, omit the oil seal and felt ring. The full procedure will be dealt with later.

The flywheel can be removed after removing the clutch and taking out the attachment bolts.

Before installing the flywheel, thoroughly clean the shims and mating faces of the crankshaft and flywheel. Check the spigot needle roller bearing and renew if defective. Extract the old bearing with a suitable internal-legged extractor and impact hammer, then drive the new bearing carefully back into place with a suitable drift. If the bearing is satisfactory, lubricate it lightly with lithium-based grease. Check the condition of the oil seal 10 and renew it if defective or worn. Moisten the felt ring 3 with clean engine oil and wipe away the surplus. Lightly oil the running surface on the flywheel where it will contact the oil seal. Install the flywheel, with shims in place, and tighten the attachment bolts to a torque of 12.5 kg m (90 lb ft).

It is advisable to check the runout on the flywheel after it has been installed. Mount a dial indicator gauge as shown in **FIG 1 : 27** and press the crankshaft fully forward to take up the end play, then check the runout by slowly cranking the engine over. Excessive runout can be caused by specks of dirt between crankshaft and flywheel but if it cannot be cured by cleaning or light skimming a new flywheel should be installed.

1 : 10 The crankcase assembly

One side casting together with the crankshaft, camshaft and related parts are shown in **FIG 1 : 2**. The engine must be removed from the car, and the cylinder heads as well as cylinders removed before the castings can be parted to gain access to the crankshaft, crankshaft bearings, camshaft, camshaft bearings and cam followers (tappets). It will also be necessary to remove the air ducts, cooling fan, and its hub. The cooling system parts are dealt with in **Chapter 4** and the cooling fan is secured to the hub by three bolts.

Oil seals:

The rear end of the camshaft is sealed by the bore end cover while the front end is sealed by the attachment of the oil pump and its gasket.

The rear oil seal for the crankshaft is dealt with in the previous section and can be renewed after the removal of the flywheel.

To gain access to the front oil seal it is necessary to remove the cooling air ducts. Press off the cooling fan hub, preferably using the special tool VW.185 as shown in **FIG 1 : 28**, after removing its attachment bolt and washer. Prise out the old oil seal, taking care not to damage the castings. Slightly chamfer the outer edge of the bore to remove any burrs, and clean out the bore. Lightly smear the periphery of the new seal with sealing compound, lubricate the lips with grease, and drive it back into position, preferably using the special drift VW.191. Install the cooling fan hub and tighten its bolt to a torque load of 2.8 kg m (20 lb ft). Install the cooling parts.

Parting castings:

Remove all the parts mentioned earlier in this section. It is advisable to remove the flywheel as well. To prevent damage, the pistons should also be removed and great care taken not to allow the connecting rods to fall heavily against the castings. Rags wrapped around the connecting rods will protect the castings.

Evenly slacken all the nuts securing the two castings and remove the nuts. Do not pry between the castings in an effort to part them, as this will cause damage to the mating faces. Tap gently and evenly all round the joint with a rubber mallet to dislodge the righthand half casting. When the castings have been parted, remove the components.

Clean the castings with a suitable solvent and blow through all oilways and passages with compressed air. Clean and check the mating faces of the crankcase castings. Soften any jointing material with trichlorethylene or similar solvent and then scrape it off with a tool made of perspex or hardwood. Slight chips or burrs should be smoothed down with an oilstone or by careful use of a scraper. The two castings are a matched pair and if either one is defective, both must be renewed as a set.

Before finally assembling the engine, bolt the two castings together and check the bores of the crankshaft main bearings and camshaft bearings for wear, ovality or taper.

Tappets (cam followers):

When the castings have been parted, withdraw the tappets from their bores and store them in their correct order.

Check each tappet in turn for scoring or wear on the cylindrical surface or chipping or other damage on the flat surface. Check that the tappet slides freely in its bore. Discard any defective tappets and fit new ones in their place.

Crankshaft bearings:

Remove the crankshaft from between the castings. Each connecting rod and its cap should be marked with a numeral indicating position or a code of dots. The connecting rods must be installed back into their original positions so note the direcction in which the markings face.

Slacken both nuts on each connecting rod, then remove them and take off the bearing cap. Ease the cap off with light hammer blows if it sticks in place. Leave the bearing inserts in place and temporarily refit the caps loosely to the connecting rods so that there is no danger of intermixing inserts or caps.

Measure each crankpin at several points to determine wear, ovality or taper. If there is excessive wear or scoring, the crankshaft will have to be reground and new undersized bearing inserts fitted.

Similarly check the crankshaft journals and have them reground if necessary.

Thoroughly clean the crankshaft. Blow through the oilways with paraffin under pressure followed by compressed air (use a syringe and tyre pump if nothing else is available). This is particularly important if the crankshaft

has been reground or a bearing has run, as swarf or metal may otherwise remain and be forced into the bearings by the oil pressure when the engine is running. If the engine is to be left dismantled for any length of time, wipe over the journals and crankpins with an oily rag (or smear them lightly with grease) to prevent corrosion.

Examine the bearing inserts. If any show signs of cracking, pitting, wearing or cracking on the surface, renew the complete set. Check the big-end bearing inserts for signs of undue wear which could indicate connecting rod distortion.

New bearing inserts are fitted as received, apart from cleaning, and do not require boring or scraping to make them fit. Under no circumstances should shims be fitted or parts filed to alter the clearance of the bearings, in an attempt to take up wear.

The old connecting rod nuts and bolts should be discarded and new ones installed on reassembly. Clean the crankpin thoroughly again and make sure that the bore in the connecting rod and cap is scrupulously clean. Wipe the bearing inserts with a piece of leather and insert them back into their respective positions, making sure that the tag is correctly located. Lubricate the crankpin with clean engine oil or graphited-oil and fit the connecting rod back into place, tightening the nuts to a torque of 3.3 kg m (24 lb ft) and locking them by peening. Check that the connecting rod rotates freely about its crankpin, easing any tension by lightly tapping as shown in **FIG 1 : 29**. Lay aside the assembly, covering it over to stop it from becoming dirty, ready for reassembly of the engine.

Camshaft:

The camshaft driving gear is made of light-alloy and is riveted to the camshaft.

Wash the camshaft in solvent and check for wear or damage. Measure the journals and examine the bearing inserts in the same way as for the crankshaft bearings.

Slight pitting at the lobes of the cams is fairly common and light score marks can be polished off with an oilstone. If the cams are excessively scored install a new camshaft, but note that in some cases it is possible to have cams reground.

Mount the camshaft between the centres on a lathe and use a dial indicator gauge to check the runout at the centre journal. Normally the runout should be within the limit of .02 mm (.0008 inch) but the wear limit is .04 mm (.0016 inch).

The front bearing inserts for the camshaft are fitted with flanges which control the camshaft end play. Lay the bearings back into one crankcase casting, after careful cleaning, and use a dial indicator gauge to measure the end play, as shown in **FIG 1 : 30**. The normal limits are .04 to .13 mm (.0016 to .005 inch) and new thrust bearings must be fitted if the wear limit of .16 mm (.0063 inch) is exceeded.

Lay the crankshaft and its main bearings into the casting and check the backlash between the timing gears. The backlash limit is .05 mm (.002 inch) which is hardly perceptible. Various sized timing gears are available in $\frac{1}{100}$ mm variations to adjust the backlash. Markings -1, 0, $+1$ and $+2$ are made on the back of the gears (do not confuse with valve timing marks) to indicate the size of the gear.

Crankshaft gears:

The crankshaft timing drive gear is supplied in one size only. Both gears and spacer can be removed by pulling them off with a suitable extractor after the retaining clip has been removed.

Check for damage on the crankshaft and smooth down with an oilstone if required. The gears must be a tight press-fit and if they are loose it is possible to have the surface built up so that they are again a tight fit, without having to fit a new crankshaft. Such building-up should be left to a specialist firm.

Special tools VW.428 and VW.415A are made for pressing the gears back into position but a press and suitable spacers may be used. Before installing the gears it is essential to heat them in an oil bath to a temperature of at least 80°C (196°F). This can be done by immersing them in a tin of oil and heating the oil in boiling water. Once the gears have cooled, check that they are a tight fit.

Assembling the crankcase:

The connecting rods should already have been fitted to the crankshaft and checked for free rotation. Wipe off any protective from the crankshaft journals and clean them thoroughly.

Lubricate the bores for the tappets and slide the tappets back into place. To prevent the tappets from falling out it is advisable to hold them in place with clips made out of springy wire, as shown in **FIG 1 : 31**.

Refit any stud seals and check that the bearing dowels in the castings are secure. Give a final wipe to the bearing bores in the castings and to the bearing inserts with a piece of leather. Fit the crankshaft No. 3 main bearing insert shells and camshaft bearing inserts back into position in the castings. Wipe the Nos. 1 and 4 crankshaft main bearing inserts, lubricate them liberally with oil and slide them back onto the crankshaft. Lubricate the bearings in the lefthand side casting and lay the crankshaft and camshaft back into place. Smear a little jointing compound around the camshaft bore end cover and fit it back into position, as arrowed in **FIG 1 : 32**. The camshaft and crankshaft must be fitted so that the two dots on one of the gears are on either side of the circle on the other gear, as shown in **FIG 1 : 33**. This ensures that the valve timing is correct. Note that the marks are on the front of the gears, so do not confuse size marks on the back of the camshaft gear with timing marks.

Smear a little jointing compound evenly around the mating faces of the two crankshaft castings. Take great care not to put on so much compound that it creeps into bearings or blocks oilways.

Lower the other casting down into place and progressively tighten the nuts to a torque of 2 kg m (14 lb ft). Check that the crankshaft and camshaft rotate freely, taking care to support the connecting rods.

The remaining parts are then installed in the reverse order of removal.

Crankshaft end play:

Leave the crankshaft oil seals off and install the flywheel with two shims (items 11 shown in **FIG 1 : 26**). Mount a dial indicator gauge onto the crankcase, as shown in **FIG 1 : 27** and lever the crankshaft firmly in and

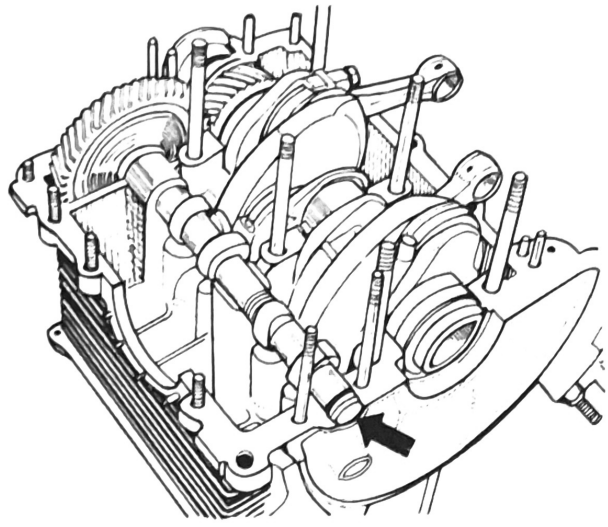


FIG 1:32 Fitting the camshaft bore end cover

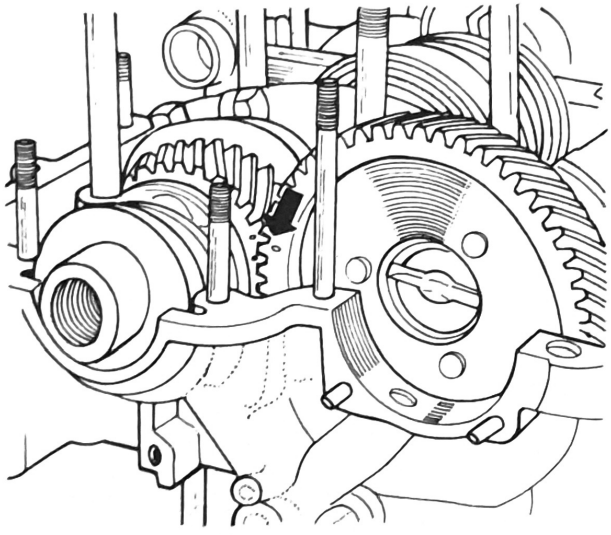


FIG 1:33 Correctly aligning the valve timing marks

out so that the end play can be measured. By noting the end play with two shims only, calculate the thickness of the third shim to give a total play of .07 to .13 mm (.0027 to .0051 inch). Shims are available in thicknesses of .24 mm, .30 mm, .32 mm, .34 mm, .36 mm and .39 mm and the size is etched on them (though it is advisable to check them with a micrometer if they have been used previously. If the end float is checked without dismantling the engine no action need be taken until the wear limit of .15 mm (.006 inch) is reached.

Excessive crankshaft end play can cause a knock in the engine, particularly at slow speeds, and the knock will stop when the clutch is operated.

Once the three shims have been selected to give the correct crankshaft end play, install the oil seals and felt ring, then finally install the flywheel.

1:11 Reassembling a stripped engine

Removal of the crankshaft and separation of the crankcase castings requires full dismantling of the engine so therefore most of the details have been covered in the previous section. Installation of the remainder of the parts is dealt with in the relevent sections. Fitting the distributor drive gearshaft is dealt with in **Chapter 4**.

This section will give the best order for reassembly as well as a few hints and tips that will save aggravation.

When the engine has been first removed from the car, blank off any apertures and wash down the exterior of the engine. Paraffin (or fuel) may be used to remove the worst of the dirt followed by another wash to thoroughly clean the exterior. Alternatively proprietary dirt-dissolving agents may be used followed by washing with water.

As parts are removed they should again be cleaned and any bright metal surfaces wiped over with grease to prevent corrosion. Have a small tin of fuel at hand so that nuts, bolts and small parts can be dropped straight into it for cleaning of threads. Sludge will accumulate in the bottom of the tin so either discard the dirty fuel regularly or have another tin in which the parts can be given a final swill.

Put the appropriate nuts, bolts and washers and small parts into bags and tie them to the main component. Note the positions of any special bolts or those that are longer or shorter than standard and if a sketch is used it can be taped to the bag. Usually all nuts, bolts, washers and odd little parts are dropped into one large cardboard box (which either breaks or gets knocked over) and there is a frantic search to find the appropriate size of nut or bolt when it comes to reassembly.

Have a special storage area where the parts can be laid out in order. Keep them in boxes and wrap them in newspaper to prevent them collecting dirt.

Before starting reassembly, clear the bench or working area and brush it clean. Lay clean paper over it so that parts can safely be laid down.

The components should have been checked as they are removed and cleaned but make sure that all threads are satisfactory, dowels and studs securely in place, flanges true, and castings not cracked.

All old seals and gaskets should have been discarded so new ones should be used throughout on reassembly. Metal parts may be safely washed in harsh solvents, such as trichlorethylene or carbon tetrachloride, and this type of solvent must be used to soften and remove traces of sealing or jointing compound. Scrape light-alloy castings with tools made of hardwood or perspex only.

All bearing surfaces should be liberally lubricated with engine oil or graphited oil as parts are installed. At the most, judicious tapping with a rubber mallet should be used (except when a press is required) for the assembly of parts. Do not use brute force if parts will not fit together, but dismantle them again so that the cause can be found. Check that parts move as they should after they have been fitted.

Start by fitting the connecting rods to the crankshaft. Slide the bearing back into place and then press on the crankshaft drive gears. Fit tappets and bearing inserts into place then bolt the crankcase halves together with the crankshaft and camshaft in place. Do not forget to align the valve timing marks when fitting crankshaft and camshaft.

Adjust the crankshaft end float by selectively fitting the shims under the flywheel. Fit the crankshaft oil seals and install the cooling fan hub and flywheel.

Fit the pistons to their correct connecting rods, making sure that the arrow points towards the flywheel end of the engine. Slide on the cylinders and install the cylinder heads. Adjust the valve clearances with the engine on the bench and then fit the rocker covers. Fit old sparking plugs to prevent dirt falling through the plug holes.

Install deflector plates and cooling system components. Accessories such as the oil filter, fuel pump and distributor should be left until last.

Once the engine has been assembled, install it back into the car and set the fuel system and ignition systems to their static settings. Fill the crankcase to the correct level with fresh oil and add a little extra for the oil filter and for filling the oilways, noting that the level must be topped up to the maximum mark after the engine has been run and the level settled.

While the engine is being reassembled, have the battery charged up so that it is at full capacity. Remove the old sparking plugs and crank the engine on the starter motor to prime the fuel system, oil system and to check that the engine rotates freely without binding.

Install the correct sparking plugs and start the engine. If the engine fails to start, work through systematically to check for faults. When the engine does start it will sound rough and will smoke as the excess lubricant is burnt out of the combustion chambers and bores. Smoke may also be produced as greasy marks burn off the cylinders and hot exhaust pipes.

Allow the engine to warm up before making final adjustments to ignition and fuel system.

1:12 Fault diagnosis

(a) Engine will not start

1 Defective ignition coil or distributor cap
2 Defective distributor capacitor
3 Dirty, pitted or incorrectly operating ignition contacts
4 Ignition wires loose or insulation faulty
5 Water or dirt on HT leads
6 Battery discharged, loose or dirty battery terminals
7 Faulty or jammed starter motor
8 HT leads incorrectly connected
9 Defective fuel pump
10 Vapour lock in fuel lines (hot weather only)
11 Over- or under-choking
12 Blocked pump filter, defective injectors or blocked jets
13 Leaking valves
14 Sticking valves
15 Valve timing incorrect
16 Ignition timing incorrect

(b) Engine stalls after starting

1 Check 1, 2, 3, 4, 5, 10, 11, 12, 13 and 14 in (a)
2 Defective or incorrectly set sparking plugs
3 Retarded ignition
4 Mixture too weak
5 Water in fuel system
6 Fuel tank breather pipe blocked
7 Incorrect valve clearances

(c) Engine idles badly

1 Check 2 and 7 in (b)
2 Air leaks at manifold joints
3 Fuel system incorrectly adjusted
4 Automatic choke not operating correctly
5 Too rich a mixture
6 Worn piston rings
7 Worn valve stems and guides
8 Weak exhaust valve springs

(d) Engine misfires

1 Check 1, 2, 3, 4, 5, 8, 9, 12, 13, 14, 15 and 16 in (a); 2, 3, 4 and 7 in (b)
2 Weak or broken valve springs

(e) Engine overheats (see Chapter 4)

(f) Compression low

1 Check 13 and 14 in (a); 6 and 7 in (c) and 2 in (d)
2 Worn piston ring grooves
3 Scored or worn cylinder bores
4 Dirty air cleaner or defective strangler valve

A high compression test pressure indicates excessive deposits in combustion chamber.

(g) Engine lacks power

1 Check 3, 10, 12, 13, 14, 15 and 16 in (a); 2, 3, 4 and 7 in (b); 6 and 7 in (c) and 2 in (d). Also check (e) and (f)
2 Leaking joints or gaskets
3 Fouled sparking plugs
4 Automatic ignition advance not operating

(h) Burnt valves or seats

1 Check 13 and 14 in (a); 7 in (b) and 2 in (d). Also check (e)
2 Excessive carbon or deposits in combustion chamber

(j) Sticking valves

1 Check 2 in (d)
2 Bent valve stems
3 Scored valve stems or guides
4 Incorrect valve clearance

(k) Excessive cylinder wear

1 Check 11 in (a) and also check (e)
2 Lack of oil
3 Dirty oil
4 Piston rings gummed up or broken
5 Piston rings badly fitted
6 Bent connecting rod
7 Dirt under cylinder seatings (causing cylinder to be tilted)

(l) Excessive oil consumption

1 Check 6 and 7 in (c); 3 in (f) and also check (k)
2 Ring gaps too wide
3 Oil return holes in piston blocked with carbon
4 Oil level too high
5 External leaks through loose attachments or poor gaskets
6 Defective oil seals
7 Oil level too high

(m) Bearing failure

1 Check 2, 3 and 6 in (k)
2 Restricted oilways
3 Worn journals or crankpins
4 Oval or tapered bearing bores
5 Loose big-end bearing caps
6 Extremely low oil pressure

(n) Low oil pressure

1 Check 2 and 3 in (k) and 2, 3 and 4 in (m)
2 Choked oil strainer
3 Defective relief valve
4 Faulty indicator or oil pressure gauge and connections

(o) High fuel consumption (see Chapter 2)

CHAPTER 2

THE FUEL SYSTEM

2:1 Description

All models are fitted with a fuel tank at the front of the car and an oil-bath type air cleaner is fitted as standard.

Twin carburetters, one per pair of cylinders, may be fitted or an electronically controlled fuel injection system installed in place of the carburetters. The fuel injection system does not offer any advantages in fuel consumption, power, or maximum speed but it does make for much easier starting in very cold weather and it brings the emissions from the engine within the current stringent legal requirements. For these reasons, fuel injection will be fitted mainly to those models destined for the North American and Scandinavian markets.

The amount of work that can be carried out by the owner on a fuel injection system is strictly limited, as accurate meters and special test equipment are required.

Part 1 of the chapter deals exclusively with the carburetter versions while Part 2 deals only with the fuel injection system, both parts being fully self-contained.

2:2 Fuel tank

This is the only component that is common to both types of fuel system.

If filters or lines clog regularly, the tank should be cleaned. In minor cases this can be carried out by draining and refilling with clean fuel (or straining the old fuel through a chamois leather) but if contamination is excessive the tank must be removed and swilled out or renewed. Special descaling solutions are made for cleaning the fuel tank after it has been removed.

The filler pipe and fuel tank sender unit are accessible after removing the covers at the rear of the luggage compartment but to remove the fuel tank it is necessary to take off the front axle carrier complete with related parts as well as removing the brake line between the master cylinder and T-piece.

2:3 Evaporative emission control

Some models, particularly those for the Californian market, may be fitted with a carbon canister to prevent fuel fumes evaporating from the fuel tank and escaping into the air.

The filler cap is sealed and the fuel tank vented to atmosphere through the carbon filled canister. Fuel fumes are adsorbed by the carbon and when the engine starts, the cooling fan blows air through the canister to purge it of fuel fumes. The air from the canister when the engine is running is then led into the air cleaner so that fuel fumes are burnt in the combustion chambers.

The carbon canister is designed to cope with fumes and not liquid fuel, so if liquid fuel accidentally passes through the canister it must be discarded and a new one fitted in its place.

PART 1 THE CARBURETTER FUEL SYSTEM

2:4 Maintenance

This is confined to cleaning the filter elements at regular intervals and checking that the throttle linkage operates fully and freely. Pivot points in the throttle linkage should be lightly oiled.

Air cleaner:

The air cleaner must be removed from the engine for cleaning purposes. No hard and fast rules can be laid down as to the servicing period and in extreme dusty conditions it may even be necessary to clean the air cleaner daily. The lower portion must be cleaned when there is only 4 to 5 mm of clean oil above the sludge layer.

Disconnect the crankcase breather hose then lift the spring clip so that the air intake hose may also be disconnected from the air cleaner. Release the two clips securing the air cleaner to the engine, free the spring clips securing the ducts to the carburetters and lift out the air cleaner assembly in a horizontal position.

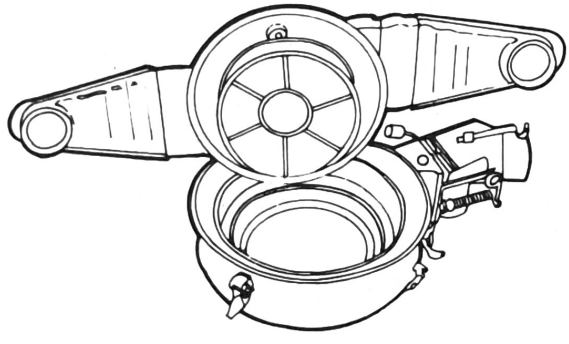


FIG 2:1 The air cleaner fitted with carburetters

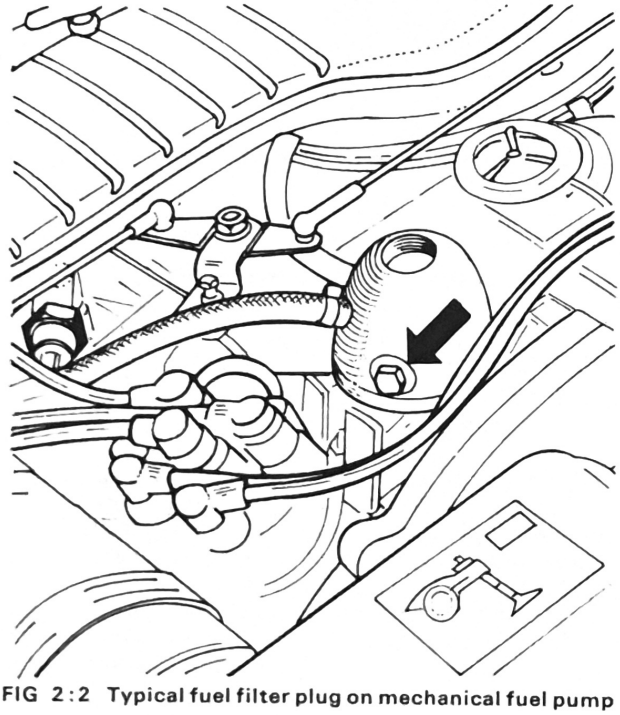


FIG 2:2 Typical fuel filter plug on mechanical fuel pump

The top portion of the air cleaner can be removed after freeing the three clips securing it to the base. **Do not lay the top portion so that the filter element is upwards.**

Clean out the lower portion of the air cleaner, removing all sludge and old oil. Fill it to the mark with fresh oil (approximately .45 Litre, .8 Imp pint). Normally SAE.30 oil should be used but oil as thin as SAE.10 may be used in arctic climates. The upper portion filter element should not normally require cleaning and if it does then scraping off dirt with a piece of wood is sufficient. Only in extreme cases should the filter element be swilled in paraffin (kerosene) or diesel fuel. The air cleaner with the top removed is shown in **FIG 2:1**.

Install the air cleaner in the reverse order of removal, making sure that all seals and hoses are in good condition as well as seating correctly. Check that the preheater valve in the inlet operates freely.

Fuel filter:

The access plug for a typical fuel filter is shown in **FIG 2:2**. Remove the plug arrowed in the figure and withdraw the filter element. Loosely refit the plug while cleaning the element to prevent fuel from syphoning out. Swill the element clean in fuel and dry it with gentle air pressure. Examine the element for tears or other damage before refitting it in the reverse order of removal.

2:5 The fuel pump

A mechanically operated diaphragm-type fuel pump is mounted on the engine for drawing the fuel from the tank and supplying it under slight pressure to the carburetter float chambers.

A sectioned view of the fuel pump is shown in **FIG 2:3**. The pushrod 1 is actuated by an eccentric cam on the engine camshaft. The movement of the pushrod actuates the operating lever 2 so that it pulls down on the diaphragm rod. The downward movement of the diaphragm draws fuel from the tank through the inlet 9, filter 10 and inlet valve into the chamber above the diaphragm. On the return stroke, the pressure of the diaphragm spring 5 and lever spring 7 press the diaphragm up to force the fuel out through the outlet valve 4 and outlet pipe 15 to the carburetters. When the needle valves in the carburetter float chambers close, the fuel pressure will overcome the pressure of the springs and the diaphragm will be held in the down position. As soon as fuel is used, the needle valves open and the drop in pressure allows the diaphragm to move up again and then be pressed down by the action of the operating lever 2. The cut-off valve 14 is opened by fuel pressure, so that when the engine stops the valve closes and prevents fuel from dribbling or syphoning through to the carburetters.

Testing:

A brief check can be carried out to see that the fuel pump is operating. Disconnect one line from one of the carburetters and point it into a suitable container. Crank the engine over on the starter motor and if the pump is operating and the lines are not blocked there will be a good spurt of fuel at every other revolution of the engine (camshaft rotating at half engine speed).

For full checks a pressure gauge is required. The pump

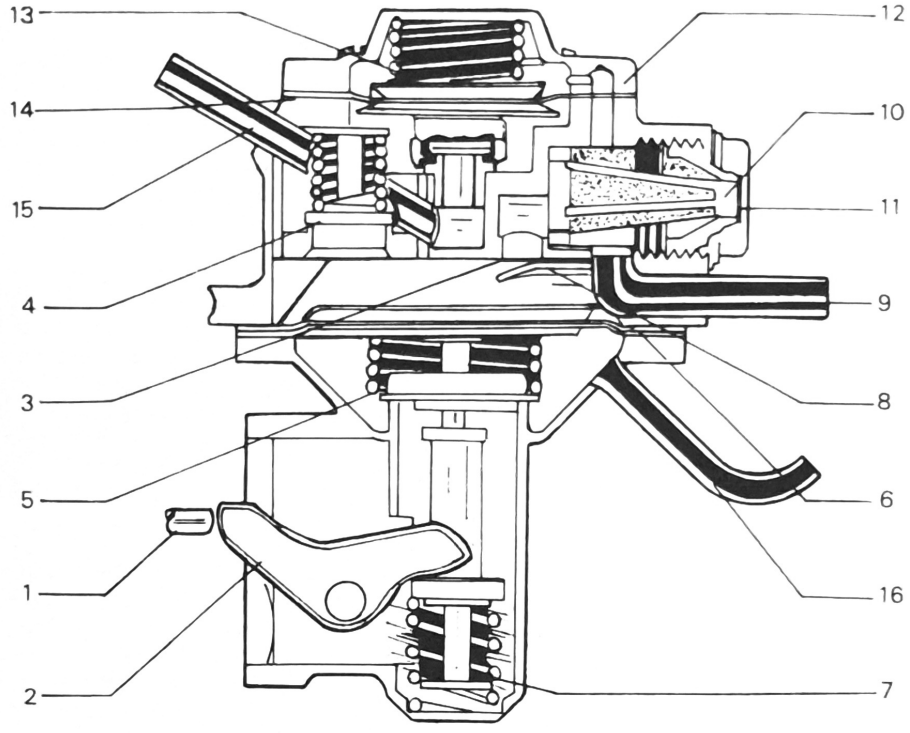


FIG 2:3 Sectioned view of the fuel pump

Key to Fig 2:3 1 Pushrod 2 Operating lever 3 Suction valve 4 Pressure valve 5 Diaphragm spring 6 Diaphragm 7 Spring for lever 8 Suction valve retainer 9 Fuel inlet 10 Filter 11 Plug with washer 12 Cover for upper part 13 Spring 14 Cut-off valve 15 Fuel outlet connection 16 Breather pipe

should maintain a fuel pressure of approximately .3 kg/sq cm (4.5 lb/sq inch) with the engine running at a 3800 rev/min. High fuel pressure will only be caused by a hardening diaphragm or having incorrect springs fitted, but low pressure can be caused by many defects ranging from general wear to partiallly blocked fuel lines.

If the pump is satisfactory, the fuel delivery pressure can be adjusted by altering the thickness of gasket between pump and engine.

If a graduated container, T-piece and suitable tap are available the fuel delivery flow should be checked. The pump should deliver 400 cc of fuel in one minute at an engine speed of 3800 rev/ min.

When testing the pump, take adequate precautions against fire.

Removal:

Usually it is possible, though difficult, to remove the fuel pump while the engine is installed in the car. Should difficulty be found then it is necessary to remove the engine (see **Chapter 1, Section 1:2**).

Disconnect the lefthand side heater control box from the heat exchanger on the exhaust system. Remove the lower air deflection plate. Disconnect both fuel lines from the pump, plugging the inlet line with a suitably sized bolt to prevent fuel syphoning through. Disconnect the breather pipe. Remove the attachment nuts using a spanner held at an angle. The pump can then be removed together with its gaskets.

Before installing the pump, pack the body with universal grease (noting that if grease has been washed out it is likely that the pump diaphragm is defective). Check the protrusion of the pushrod at the highest point and if necessary adjust it to 5 mm (.2 inch) by selectively fitting gaskets. Note that the end of the pushrod with the smallest diameter must be installed towards the camshaft. Install the pump in the reverse order of removal.

Servicing:

The components of the fuel pump are shown in **FIG 2:4**.

Remove the pump and wash down the exterior to remove road dirt. Make light file marks across the flanges to ensure that the parts will be reassembled in the correct alignment.

Take out the screws 1 so that the top cover and cut-off valve assembly parts can be removed. Remove the plug 6 and withdraw the filter 8 and washer 7. Remove the screws 9 securing the upper pump body half 10 and remove the upper body. The valves can then be removed from the upper body if required. Remove the clip 11 and pull out the lever spindle 12 so that the operating lever 13 can be removed. The diaphragm assembly complete with springs can now be removed.

Check the valves for damage, distortion or weak springs. They can be tested by gently sucking and blowing through them while fitted. **If the valves are removed it is essential to install them correctly,** with the machined side of the disc towards the valve seat, otherwise the pump will not operate.

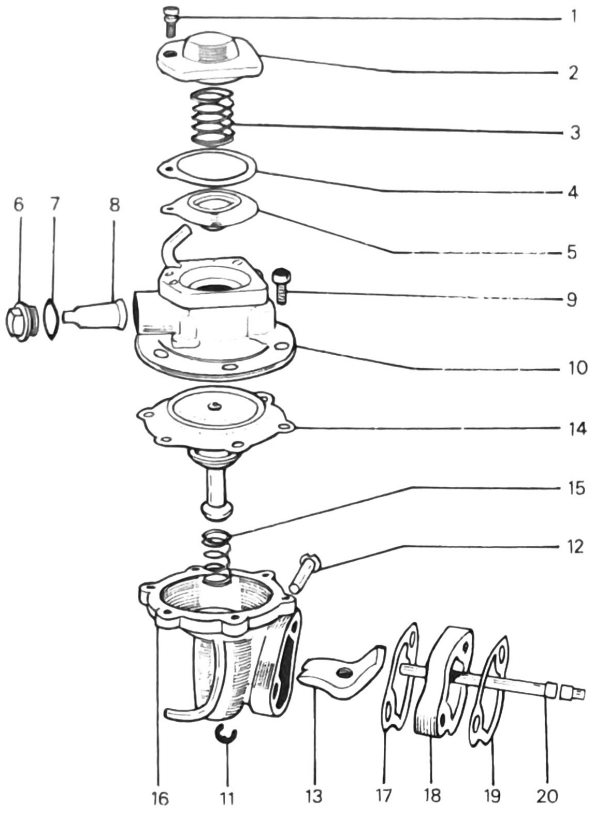


FIG 2:4 The components of the mechanical fuel pump

Key to Fig 2:4 1 Screw with spring washer 2 Pump cover 3 Spring for cut-off valve 4 Gasket for cut-off valve 5 Cut-off valve 6 Plug 7 Sealing washer 8 Filter strainer 9 Screw with spring washer 10 Upper pump body half 11 Circlip 12 Lever spindle 13 Pump lever 14 Diaphragm and spring 15 Diaphragm spring 16 Lower pump body half 17 Gasket 18 Intermediate flange 19 Gasket 20 Pushrod

Clean the interior of the castings and check them for cracks or damaged flanges. Light damage to flanges should be smoothed down with a file or scraper, making sure that mating flanges meet squarely.

Check the diaphragm for hardening or any splits or pinholes. Check the springs for distortion, corrosion or weakening.

Renew all defective parts, noting that if there is excessive general wear it will be simpler and more efficient to install a new pump.

Reassemble the pump in the reverse order of dismantling, making sure that the two valves are correctly fitted. The special plate VW.797/3 should be bolted to the attachment flange, or push the operating lever arm in by 5 mm (.2 inch) from the flange face to locate the diaphragm correctly when tightening the screws 9. The screws should be tightened progressively and in a diagonal sequence.

Fill the pump body with universal grease before installing the pump.

2:6 Carburetter operation

A sectioned view of a typical carburetter is shown in **FIG 2:5**. The float 27 rides on the fuel to operate the float needle valve 4 and 5 so that no more fuel enters when the level is correct. At idling speed, the main suction is in the bore beside the throttle valve 34 and the mixture is drawn through the port controlled by the idle mixture screw 29. Further ports are fitted to ensure a smooth transition from idle to main jets. At full throttle opening fuel and air emulsified together are drawn out through the discharge arm 36 by the suction in the venturi.

When accelerating, the fuel flow lags behind the air flow because of greater inertia of the fuel. A throttle operated accelerator pump is fitted to inject extra fuel to keep the mixture strength correct during acceleration. Fuel is drawn in from the float chamber as the throttle closes and injected into the air stream as the throttle opens. The ball valves 25 and 26 make sure that fuel is pumped through and not returned to the float chamber or air drawn in on the return stroke.

The idling jet is controlled by a solenoid. When the ignition is switched on the solenoid opens the idle jet and allows the engine to idle. As soon as the ignition is switched off, the solenoid closes the idle jet and prevents running-on. The solenoid is fitted with a grubscrew for adjustment. With the engine running at idle, set the grubscrew so that the engine cuts immediately the wire is disconnected from the solenoid. The grubscrew can also be used to hold the jet permanently open in case of solenoid failure, though a new solenoid should be fitted as soon as possible to prevent running-on after stopping the engine.

An automatic choke is fitted to each carburetter. The choke valve is held in the closed position by a bi-metallic spring when the engine is cold and the ignition off. As soon as the ignition is switched on, current flows through the heating element in the choke housing cover. As the bi-metallic spring heats up it loses its tension and allows the air flow through the carburetter to open the choke valve. A vacuum piston is also fitted and this partially opens the choke valve against the action of the bi-metallic spring as soon as the engine starts, thus weakening the very rich mixture required for start. The vacuum piston also acts as an anti-stall device. If the engine falters, the vacuum is reduced and the action of the vacuum piston weakened so that the choke valve can close and restore rich mixture strength temporarily.

Altitude corrector:

This is not standard equipment but it can be fitted on cars that regularly travel between extremes of altitude.

To fit the corrector, remove the plug for the main jet from the side of the float chamber as well as the main jet, and thread the correct assembly back into their place.

The corrector contains an aneroid capsule which expands and contracts with changes of altitude and the aperture of the main jet is correspondingly varied by a needle attached to the capsule.

Starting:

By following the correct procedure, easy starting is guaranteed (provided that there are no defects which would cause the engine not to start).

When the temperature is below freezing and the engine

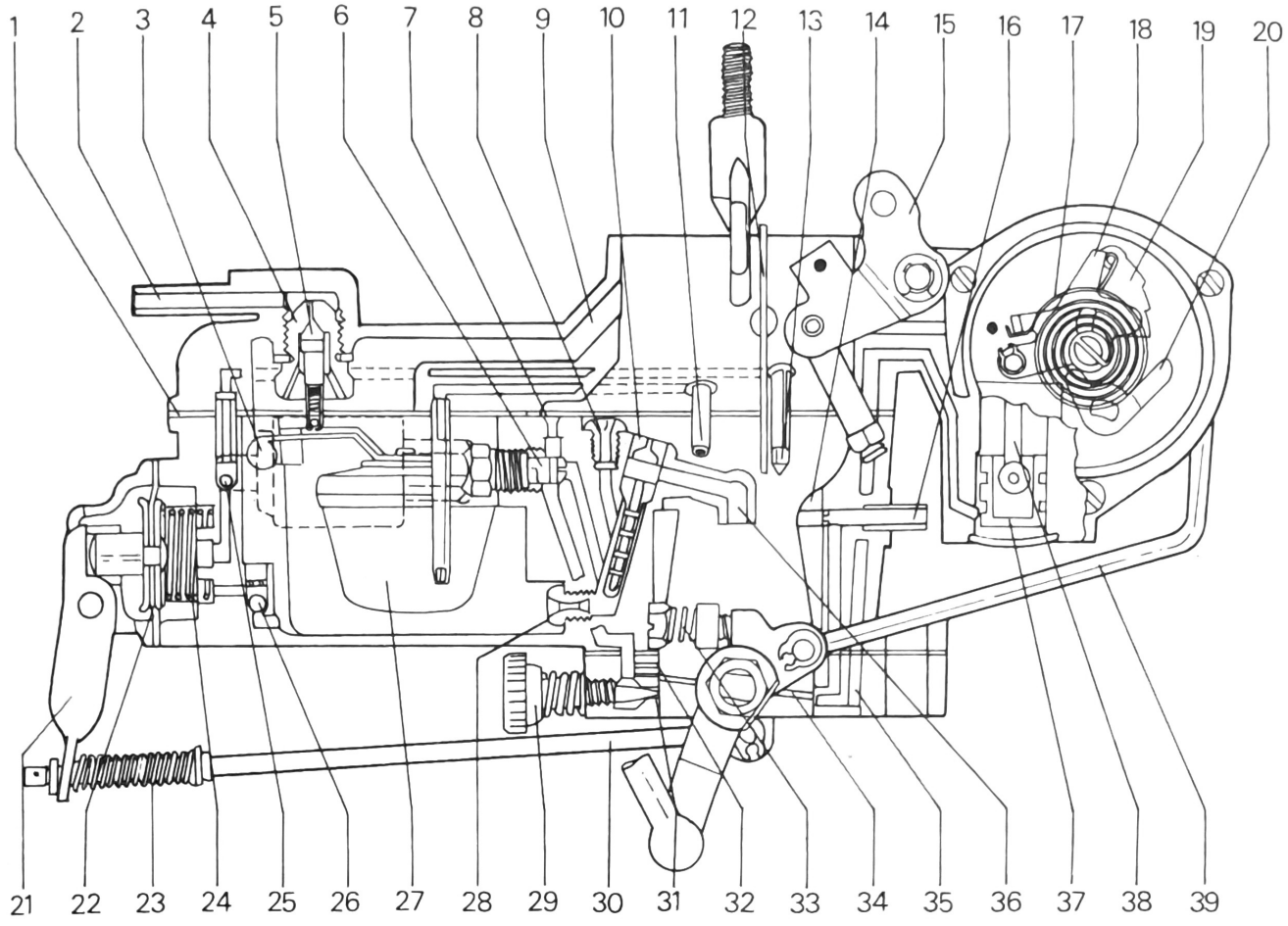


FIG 2:5 Schematic sectioned view of a typical carburetter

Key to Fig 2:5 1 Gasket 2 Fuel hose connection 3 Float hinge pin 4 Needle valve housing 5 Float needle 6 Pilot jet 7 Air bleed drilling 8 Air correction jet 9 Float chamber vent 10 Emulsion tube 11 Power fuel tube 12 Choke valve 13 Accelerator pump injector tube 14 Venturi 15 Relay lever 16 Distributor vacuum connection 17 Bi-metal spring 18 Intermediate lever 19 Fast-idle cam 20 Stop lever 21 Accelerator pump lever 22 Diaphragm 23 Spring 24 Diaphragm return spring 25 Pressure ball valve 26 Suction ball valve 27 Float 28 Main jet 29 Volume control screw 30 Connecting rod 31 Slow-running mixture outlet 32 Bypass port 33 Slow-running adjusting screw 34 Throttle valve 35 Vacuum drilling 36 Discharge arm 37 Vacuum piston 38 Piston rod 39 Operating rod

is cold, press the accelerator pedal fully down and then release it before operating the starter motor immediately after switching on the ignition.

If the engine is warm, slowly press down the accelerator pedal while operating the starter motor.

If the engine is hot, press the accelerator pedal fully down (without any pumping) and hold it there while operating the starter.

2:7 Carburetter faults

The components of the carburetter are shown in **FIG 2:6**. The carburetters should be removed and partially dismantled so that the parts can be cleaned. Special cleansing fluids are made for carburetter cleaning but many of them must be handled with care as they are caustic. Acetone or a similar suitable solvent will remove gum and deposits from parts. When cleaning the jets, swill them in clean solvent and then blow through them with compressed air. Similarly clean ports and passages. **Never poke through the jets with wire or bristle as this will wear the accurately calibrated jets.**

Service kits of spares and gaskets are available and these should be used when reassembling the carburetter.

Flooding:

Check that the appearance of flooding is not given by leaking gaskets or connections.

The most likely cause is dirt jamming the float chamber needle valve open, but it can also be caused by a worn needle, defective float, or high fuel delivery pressure.

Remove the air cleaner and take off the carburetter top cover, after disconnecting the choke operating rod and fuel supply line.

Use a box spanner to remove the needle valve assembly. It may be possible to clear dirt without removing the valve assembly, in which case leave the fuel line connected and crank the engine on the starter motor so that fuel flushes through the valve.

Check that the needle moves freely in the valve body. Hold the needle closed by light finger pressure and try to blow through the valve. If the valve leaks it must be renewed.

Withdraw the float and its pin, then check the float for punctures or defects. If the float is shaken and fuel is heard sloshing inside it then it is punctured. The point of puncture can be found by immersing the float in hot water, when the leak will show up as a stream of bubbles.

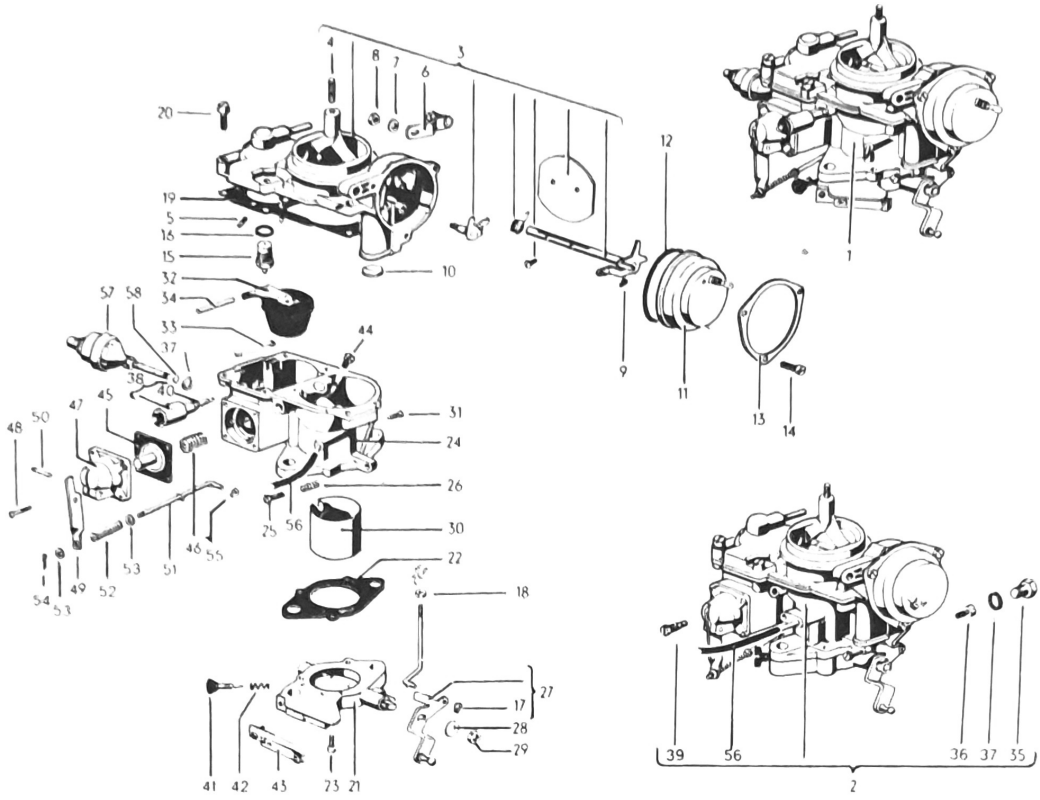


FIG 2:6 The carburetter components

Key to Fig 2:6 1 Carburetter, 34.PDSIT.2 (.3) 2 Carburetter, 34.PDSIT.2 (.3) 3 Carburetter top cover 4 Stud 5 Injector tube stud 6 Carburetter starter lever 7 Spring washer 8 Shaft nut 9 Circlip for piston rod 10 Closing washer for vacuum piston 11 Cover with bi-metal spring 12 Cover gasket 13 Cover retaining ring 14 Retaining ring screw 15 Float needle valve 16 Sealing washer 17 Connecting rod circlip 18 Connecting rod nut 19 Carburetter gasket 20 Cover screw 21 Throttle body 22 Gasket 23 Securing screw 24 Carburetter main body 25 Slow-running adjusting screw 26 Spring 27 Throttle valve lever with rod 28 Washer 29 Throttle valve shaft nut 30 Choke tube 31 Choke tube securing screw 32 Float 33 Float spindle leaf spring 34 Float spindle 35 Main jet plug 36 Main jet 37 Sealing washer 38 Idling shut-off valve 39 Slow-running fuel jet 40 Shut-off valve jet 41 Slow-running volume screw 42 Spring 43 Slow-running air valve 44 Air correction jet 45 Pump diaphragm 46 Diaphragm spring 47 Pump cover 48 Pump cover screw 49 Pump operating lever 50 Pump lever spindle 51 Pump connecting rod 52 Connecting rod spring 53 Washer 54 Splitpin 55 Circlip 56 Vacuum hose 57 Altitude corrector 58 Sealing washer

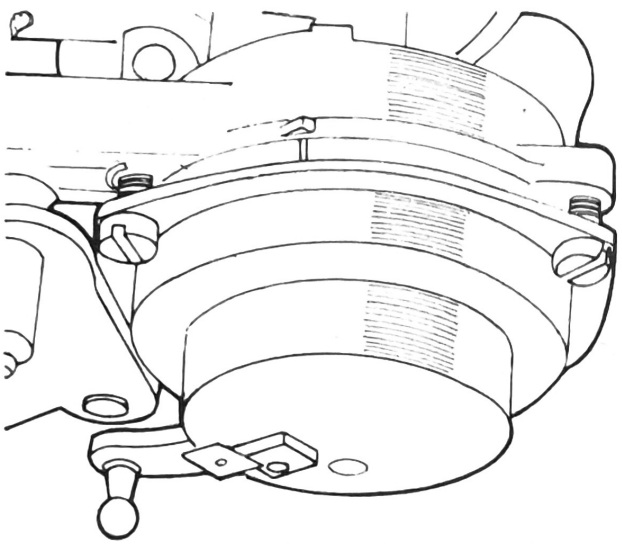


FIG 2:7 The choke housing attachments and alignment marks

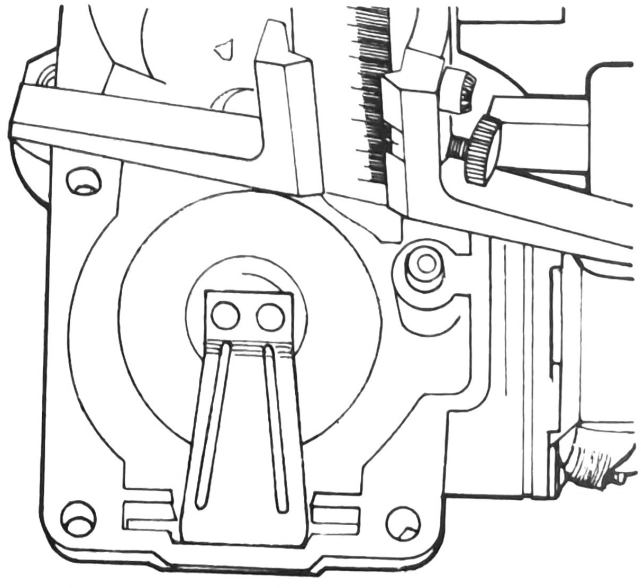


FIG 2:8 Checking the fuel level in the carburetter

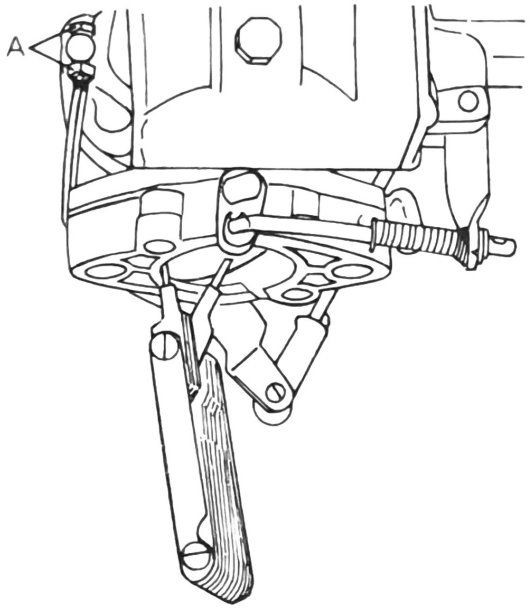


FIG 2:9 Setting the automatic choke linkage

Fuel can be driven out by alternately heating and cooling the float but solder on the float will alter its weight and it should therefore only be repaired by this method in an emergency.

Once the float and needle valve parts have been examined it is advisable to check the fuel level.

Starvation:

Starvation can be caused by similar faults to those causing flooding. The fuel delivery pressure should be checked as a low pressure can cause starvation at speed. Dirt or wear can cause the float chamber needle valve to stick in the closed position. Similarly dirt in the carburetter can block jets and cause starvation.

Check that the fuel lines are not blocked, blowing through them in a reverse direction with compressed air to clear them.

If the engine stalls after a period of running and then will not start again until some time has elapsed, remove the fuel tank filler cap as soon as possible after the engine stalls. If an inrush of air is heard and the engine will then start, the fuel tank vent system is blocked.

Poor idle may be caused by a defective idling valve solenoid valve, so check this.

Running-on:

If the fault has gradually built up over a period of time it is likely that the engine requires decarbonizing.

Check the operation of the idle jet solenoid. Use a test lamp to confirm that the wire is live when the ignition is switched on. Leaving the ignition on, brush the end of the wire across the terminal on the solenoid and if the solenoid is operating it will be heard to chatter or click as the contact is made and broken. If the solenoid does not operate, use the grubscrew to set the valve to full open so that the engine can be run.

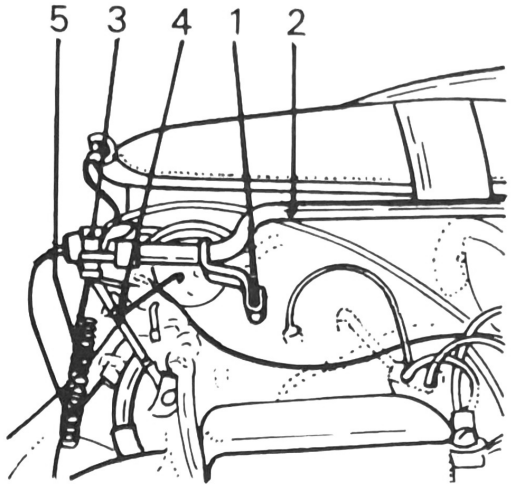


FIG 2:10 The throttle linkage at the carburetter

Key to Fig 2:10 1 Accelerator cable 2 Cross-shaft 3 Levers 4 Pullrod 5 Return spring

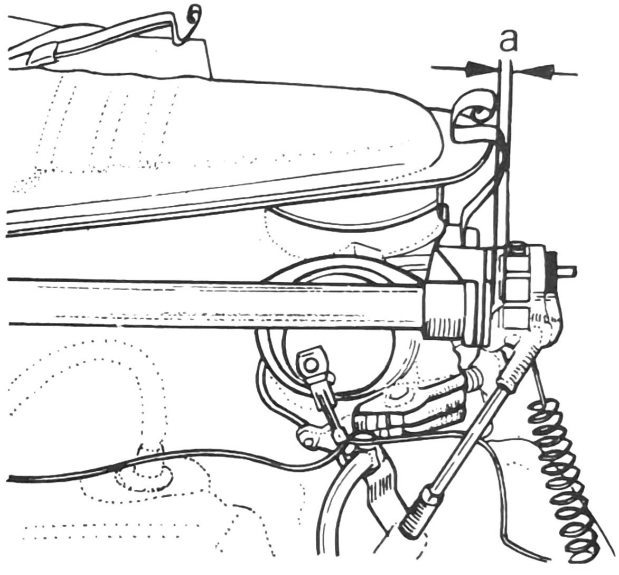


FIG 2:11 Setting the clearance 'a' for the throttle linkage

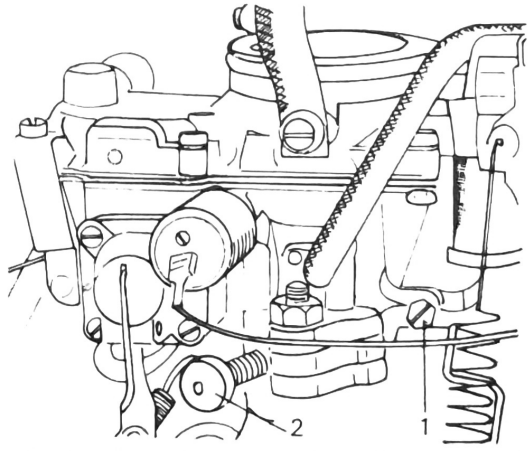


FIG 2:12 The carburetter idling adjustment points

Key to Fig 2:12 1 Idle speed adjusting screw 2 Volume control screw (mixture)

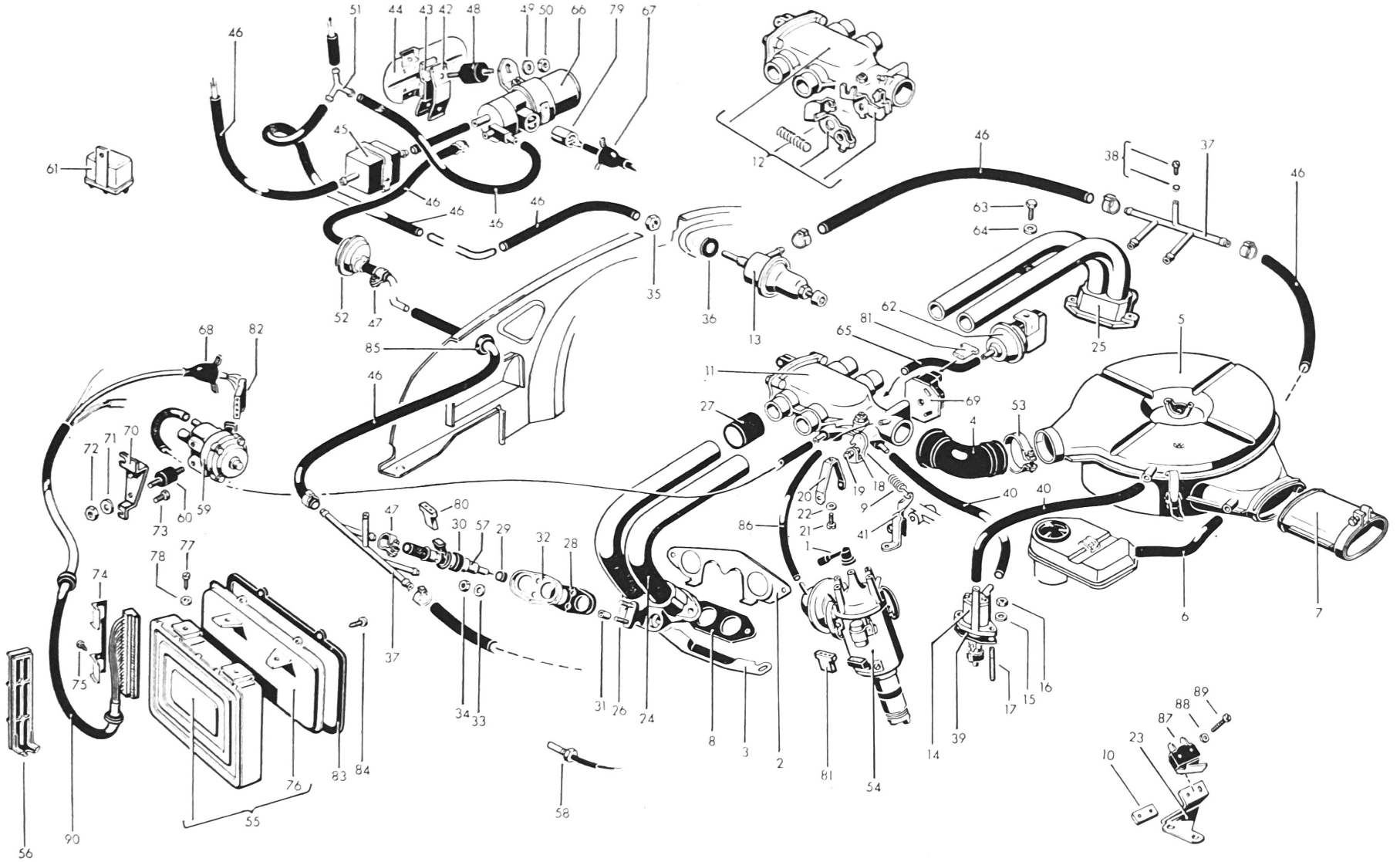


FIG 2:13 The components of a typical fuel injection system

Key to Fig 2:13 1 Connector 2 Inner cover 3 Outer cover 4 Elbow 5 Air filter 6 Hose to de-aerator 7 Intermediate piece 8 Gasket 9 Spring 10 Plate 11/12 Suction manifold assembly 13 Pressure regulator 14 Auxiliary air regulator 15 Washer 16 Nut 17 Stud 18 Pivot pin 19 Screw 20 Bracket 21 Screw 22 Washer 23 Bracket 24 Suction pipe (left) 25 Suction pipe (right) 26 Stud 27 Rubber hose 28 Valve support 29 Bush 30 Bush 31 Bush 32 Retainer plate 33 Washer 34 Nut 35 Nut 36 Insulating washer 37 Fuel injection piece 38 Screw and washer 39 Gasket 40 Rubber hose 41 Return spring bracket 42/43 Clamp 44 Protection plate 45 Fuel filter 46 Fuel flexible pipe 47 Clip 48 Flexible mounting 49 Washer 50 Nut 51 Y-piece 52 Noise damper 53 Clip 54 Distributor 55 Control unit 56 Sliding cover 57 Injector 58 Temperature sensor 59 Pressure sensor 60 Rubber bush 61 Relay 62 Pressure switch 63 Screw 64 Washer 65 Rubber pipe 66 Fuel pump 67 Rubber boot 69 Throttle switch 70 Pressure sensor bracket 71 Washer 72 Nut 73 Screw 74 Handle 75 Screw 76 Cover 77 Screw 78 Washer (shakeproof) 79 Connector cover 80 Two-way connector 81 Three-way connector 82 Four-way connector 83 Gasket 84 Screw 85 Grommet 86 Rubber pipe 87 Kick-down switch 88 Washer 89 Screw 90 Cable harness

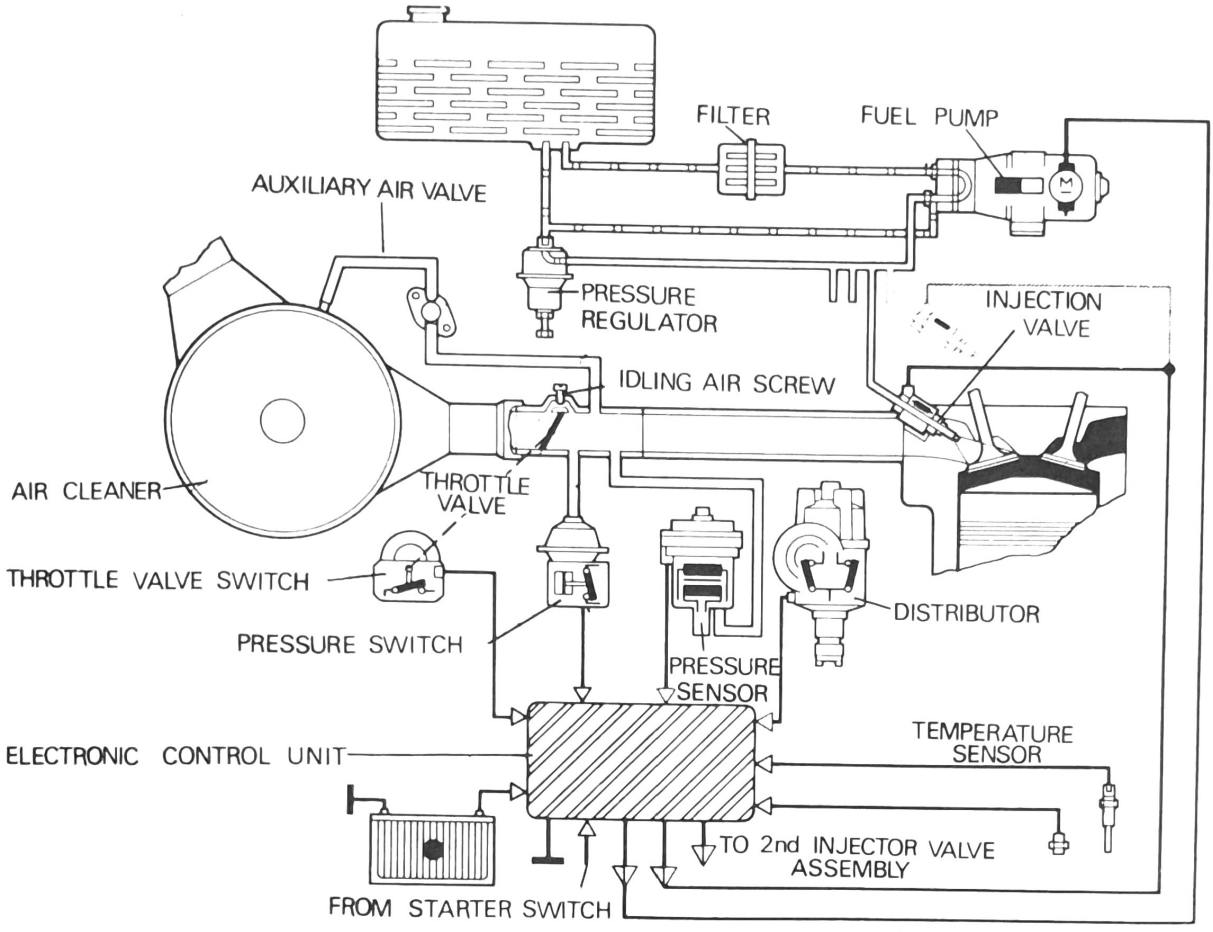


FIG 2:14 The schematic layout of a fuel injection system

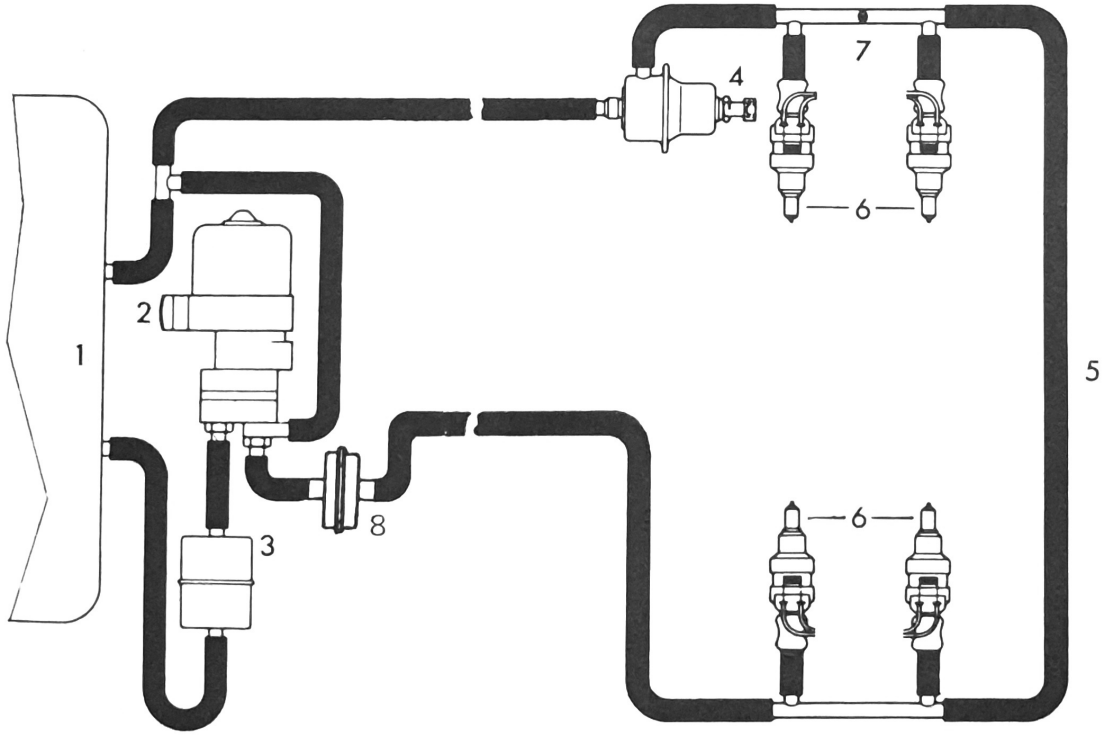


FIG 2:15 The fuel circuit

Key to Fig 2:15 1 Fuel tank 2 Fuel pump 3 Fuel filter 4 Pressure regulator 5 Fuel loop line 6 Injectors 7 Sealing screw for pressure gauge connection 8 Damper

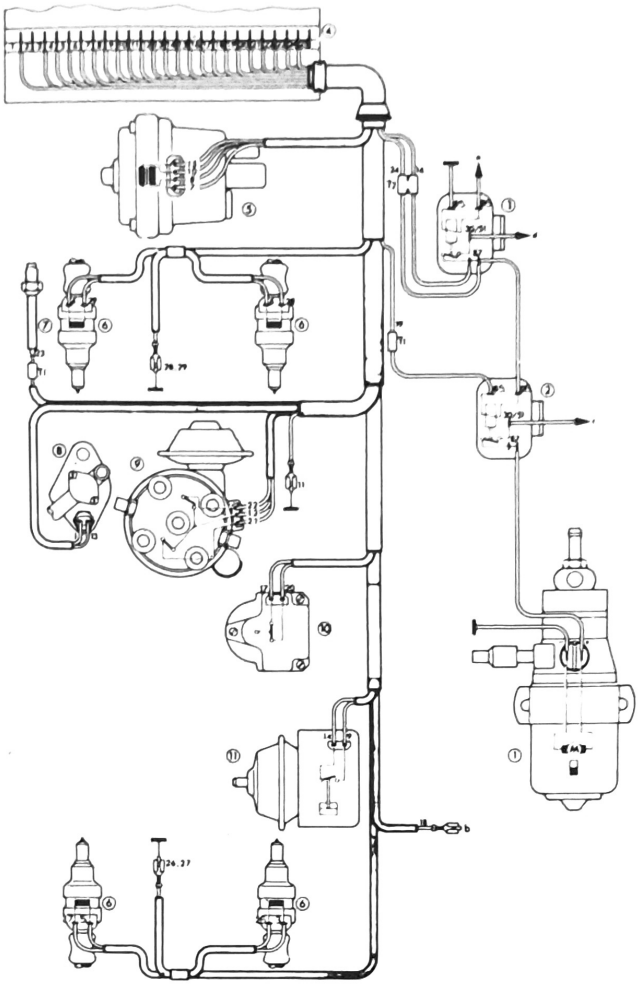


FIG 2:16 The electrical circuit

Key to Fig 2:16 1 Fuel pump 2 Pump relay 3 Voltage supply relay 4 Electronic control unit 5 Pressure sensor 6 Injectors 7 Cylinder head temperature sensor 8 Crankcase temperature sensor 9 Ignition distributor with trigger contacts 10 Throttle valve switch 11 Pressure switch **a** Wire to ignition/starter switch **b** Wire to starter solenoid terminal 50 **c** Wire to terminal 30 **d** Wire to positive battery terminal **T** Wire connector T_2 Wire connector

Choke operates incorrectly:

Check that the leads to the automatic chokes are both live when the ignition is switched on. If the choke does not release itself within five minutes it is likely that either the bi-metallic spring or the heater element is defective. In both cases the complete choke housing cover must be renewed as neither of the components is repairable. The attachments are shown in **FIG 2:7**. Remove the air cleaner to gain access and then remove the three screws securing the cover in place. Remove the cover, gasket and securing ring.

When installing the cover, make sure that the tang on the choke lever engages in the eye of the bi-metallic spring. Set the cover so that the marks shown in **FIG 2:7** are in alignment before fully tightening the screws.

Difficulty in adjusting:

Mechanical wear and damage will make it difficult to adjust the carburetters satisfactorily. The most likely points of wear are the idle volume adjusting screw itself or the throttle valve assembly. Wear on the choke valve assembly may make cold starts difficult but generally will not affect the running of the engine once warm, unless the wear is such as to jam the choke valve in the closed position.

The volume control screw has a tapered tip so that as it is turned in or out, the effective area of the port is smoothly altered. If the screw is tightened down onto its seat, or has seen long service, the tip may wear to a stepped portion. Once a step has worn into the tip, adjustment will be erratic and turning the screw will make disproportionate variations in idle mixture. **Never tighten the screw firmly down onto its seat.**

A worn throttle valve or throttle valve spindle will also make adjustment difficult. The spindle and valve can be removed after taking off the throttle linkage parts. Take out the two screws securing the throttle valve to the spindle, slide the valve plate out of its slot and withdraw the spindle. If fitting a new spindle does not take up the wear then it will be necessary to install a new carburetter. Install the parts in the reverse order of removal but before fully tightening the screws securing the valve plate to the spindle, check that the valve operates freely without binding in the bore. Once the valve is correctly positioned, fully tighten the screws and stake them over to lock them. Support the spindle when staking the screws.

Persistent trouble can be caused by air leaks at the manifold joints. Remove the carburetters and intake manifolds. Use a steel straightedge to check that the flanges are true and that they meet fully and squarely. A fine file, scraper or oilstone can be used to remove minor damage and nicks but more extensive damage can be lapped down using fine-grade grinding paste spread over a piece of plate glass. Make sure that all abrasive and filings are cleaned away before installing the parts.

2:8 Carburetter adjustments

Fuel level:

Start the engine and run it briefly to allow the fuel level to stabilize. Stop the engine and remove the carburetter top cover, clamping the fuel hose to prevent fuel dribbling into the float chamber. Remove the gasket and use a depth gauge to measure the depth of the fuel from the top of the carburetter float chamber, as shown in **FIG 2:8**. The reading should be 12 to 14 mm (.47 to .55 inch). If the level is incorrect, fit thicker or thinner washers under the float chamber needle valve body to bring the level within limits.

Accelerator pump:

If there are flat spots in acceleration, check the delivery of the pump and the direction of its jet.

Remove the air cleaner duct. Back off the idling speed adjustment screw so that the throttle valve is fully closed. Insert a small graduated container (8 to 10cc) into the opening of the carburetter and smartly operate the throttle linkage, catching the fuel from the pump discharge nozzle. Repeat the pumping a few times so that an average reading can be obtained. The pump should

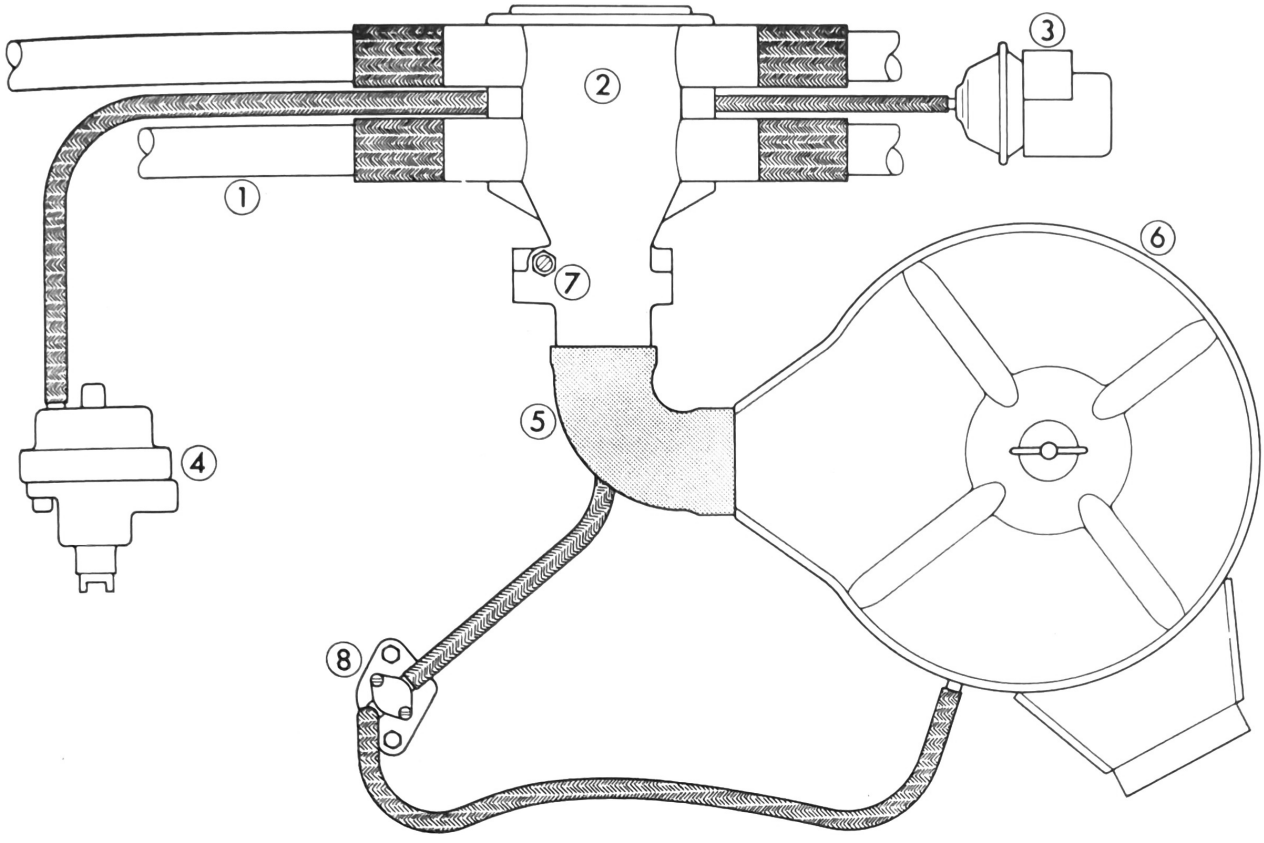


FIG 2:17 The air supply system

Key to Fig 2:17 1 Inlet manifolds 2 Air intake distributor 3 Pressure switch 4 Pressure sensor 5 Elbow 6 Air cleaner 7 Slow-running adjustment 8 Auxiliary air regulator

produce .7 to .9 cc per stroke. If the injection amount is incorrect vary the number of washers (.2 mm Part No. 111.905.231) on the operating rod to bring the amount within limits. Increase washers to increase fuel flow and decrease to decrease fuel. Only if the injection amount varies considerably from the correct amount should the operating rod be moved to another hole in the lever.

Check the depth from the end of the injection tube from the top face of the carburetter. This should be 12.5 mm. At the same time check that the direction of injection is correctly through the gap when the throttle is partially open. Carefully bend the tube to position if the injection is incorrect.

Choke adjustments:

The housing must be installed so that the marks shown in **FIG 2:7** are in alignment.

Further adjustment of the linkage can only be carried out with the carburetter removed and it will be necessary to reset the idle after the carburetter(s) have been installed.

With the carburetter removed, adjust the nuts on the rod **A**, shown in **FIG 2:9**, until the gap at the throttle valve is .8 mm (.030 inch) with the choke valve held closed. Install the carburetter and back out the idle speed adjustment screw until it is clear of lever, so that the throttle valve is fully closed. Turn in the adjusting screw until it just touches the throttle lever. Close the choke valve by briefly opening the throttle valve and pressing the choke valve if necessary. Now measure the gap between the idling speed adjustment screw and the throttle lever, using feeler gauges or a suitable diameter rod. Use the adjusting nuts on the connecting rod to set the gap to 2.6 mm (.10 inch). Adjust the idle speed.

Throttle linkage:

The attachments are shown in **FIG 2:10**. Note the lefthand lever and lefthand pullrod are adjustable while the equivalent parts on the righthand side are not.

The complete throttle linkage assembly can be removed after disconnecting the accelerator cable and springs, disconnecting the crankcase breather hose, disconnecting the pullrods from the throttle levers, and taking out the bolts securing the brackets to the carburetters.

Before installing the linkage, check the parts for wear and lubricate bearing surfaces with molybdenum disulphide. Adjust the lefthand side pullrod to a length of 104 $\pm$.5 mm and lock it at this length.

Fit the parts back into place and press down the levers at the end of the cross-shaft so that the throttle levers are in the idling positions. Push the shaft towards the left and press the lefthand side lever downwards to the right, then tighten the nut securing the lever. Push the cross-shaft to the right and slide the righthand lever towards the bracket until there is a clearance of 1.5 to 2.0 mm (.006 to .008 inch) between the lever and the bracket, as shown in **FIG 2:11**. Tighten the nut in this position.

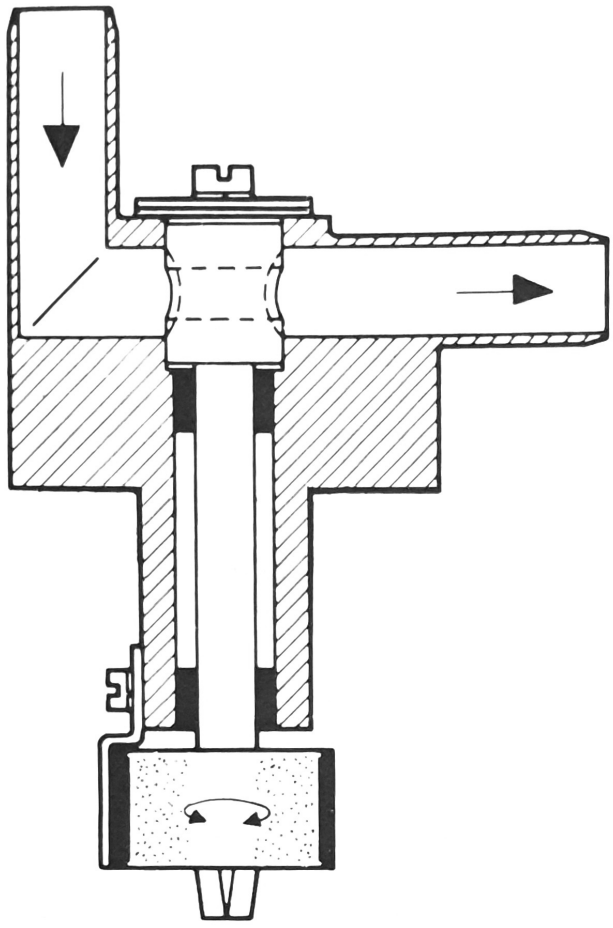


FIG 2:18 Sectioned view of the auxiliary air regulator valve

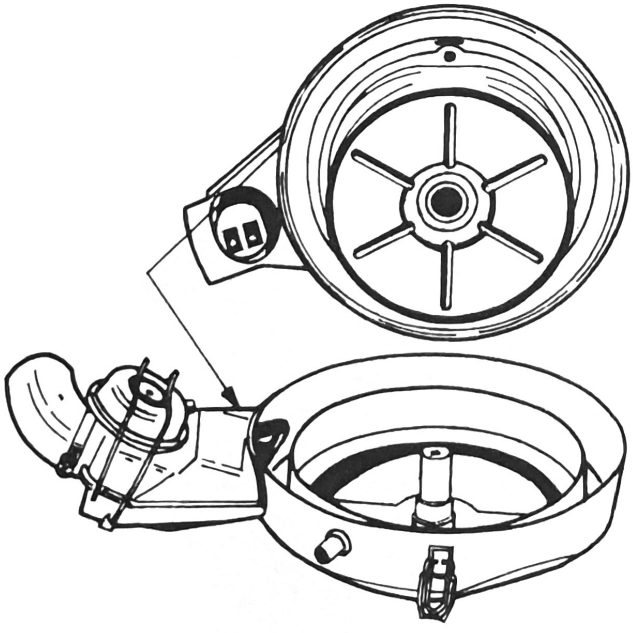


FIG 2:19 The air cleaner fitted with the fuel injection system

Attach the accelerator cable so that there is a distance of 1 mm (.04 inch) between the throttle lever and its stop at full throttle. On models fitted with automatic transmission make sure that there is sufficient further travel on the pedal to operate the kick-down switch when the throttle valves are fully open.

Idling adjustments:

The adjustment points are shown in **FIG 2:12**. It will be necessary to remove the air intake ducts. When installing these after adjustment there may be a drop in idle speed but no adjustments are required to cure this.

A balance meter should be used, though it is possible (but not recommended) to use a length of hose and listen to the hiss at the intakes so that they can be balanced by sound.

If the adjustments are totally lost they can be set to give safe running. The idle adjusting screw 1 should be set so that it is 1 turn in from the position where it just contacts the throttle lever when the throttle valve is closed. The volume control screw should be lightly seated, **do not seat it firmly as this causes wear to the tapered portion,** and then backed out by $1\frac{1}{2}$ turns.

Start the engine and run it until it has reached its normal operating temperature. Remove the air cleaner ducts, checking that both choke valves are fully open. Connect a tachometer into the ignition circuit. Use the idle speed adjustment screws to give an idle speed of 900 rev/min. Use the balance meter or some other method to check that the air flow through both carburetters is the same. Turn in the volume control screw 2 on both carburetters by equal amounts until the engine starts to run unevenly and then back them out by $\frac{1}{4}$ to $\frac{1}{2}$ turn each until the engine is running smoothly. Bring the idle speed back to 900 rev/min if necessary, using both idle speed screws 1.

Clip the throttle linkage open so that the engine is running at 1500 to 1800 rev/min. Check the balance of the carburetters using the balance meter and if necessary adjust the lefthand side pullrod to bring the carburetters into balance.

Remove the tachometer, clip on throttle linkage and install the air cleaner ducts.

2:9 Fault diagnosis

(a) Leakage or insufficient fuel delivered

1 Air vent in fuel tank blocked
2 Fuel pipes blocked
3 Air leaks at pipe connections
4 Pump filter blocked
5 Strainer on fuel tank sender unit blocked
6 Defective pump

(b) Excessive fuel consumption

1 Carburetters require adjustment
2 Dirty air cleaner
3 Sticking throttle linkage
4 Defective automatic choke
5 Jets loose or incorrect size fitted
6 Flooding or external leaks
7 Excessive engine temperature
8 Brakes binding
9 Tyres under-inflated
10 Car overloaded

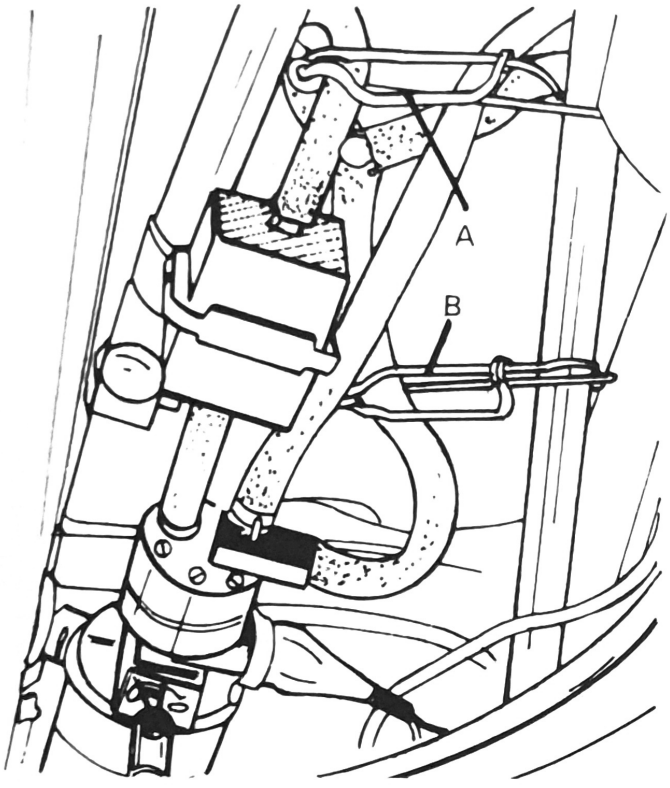


FIG 2:20 Changing the fuel filter on earlier models

(c) Engine will not start

1 Defective ignition
2 Fuel not reaching float chamber
3 Incorrect starting technique
4 Defective automatic choke cover assembly
5 Defective solenoid operated idling valve
6 Jets blocked

(d) Idling speed too high or erratic

1 Automatic choke not functioning
2 Accelerator linkage sticking
3 Incorrect slow-running adjustments
4 Defective volume control screws
5 Worn throttle valve assemblies

PART 2 THE FUEL INJECTION SYSTEM

2:10 Description

The components of a typical system are shown in **FIG 2:13** and the schematic layout of the system is shown in **FIG 2:14**. Two sensors are fitted, one measuring cylinder head temperature and the other crankcase temperature.

The fuel is drawn from the fuel tank through a renewable filter to the pump, which is electrically driven. A constant pressure is kept in the system by the action of the pressure regulator.

The electronic control unit is a cigar-box sized computer which takes in all the parameters and produces a series of pulses. These pulses, varying in duration, operate the injectors so that fuel is injected into the manifold at the correct moment. The longer the pulse, the longer will be the time that the injector is open and the more fuel will be injected.

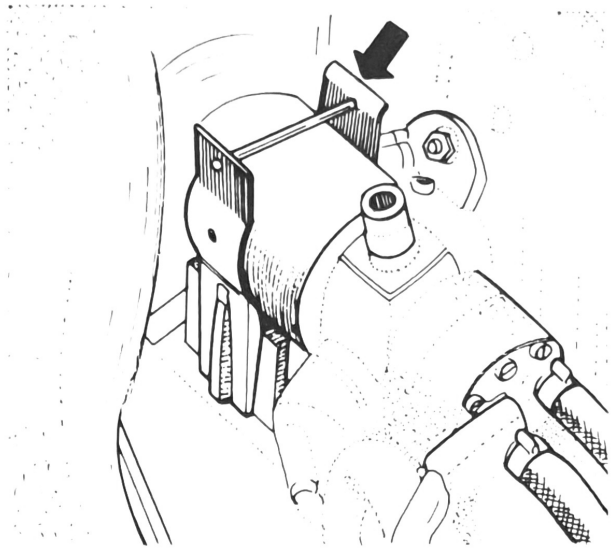


FIG 2:21 The fuel filter attachments on later models

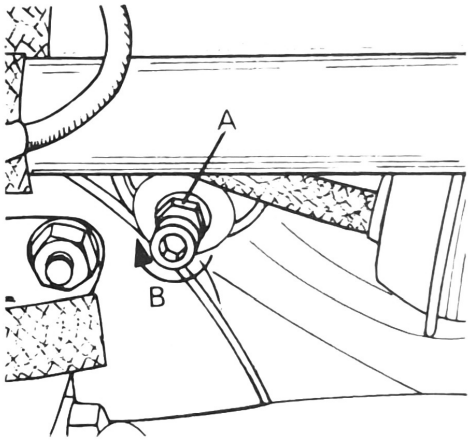


FIG 2:22 Adjusting the fuel pressure

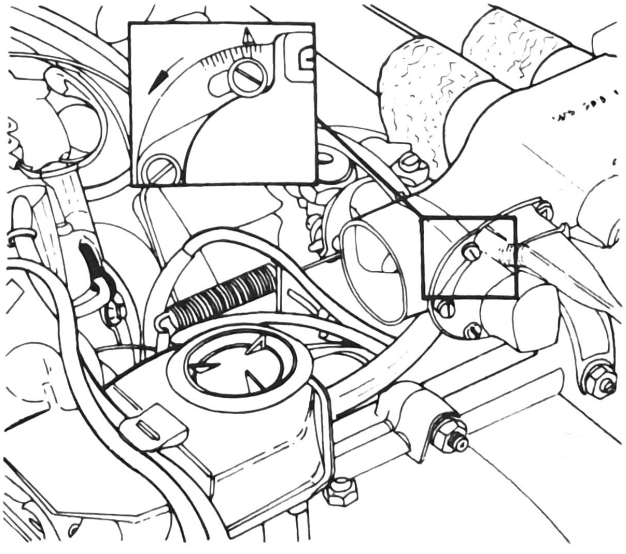


FIG 2:23 The throttle valve switch

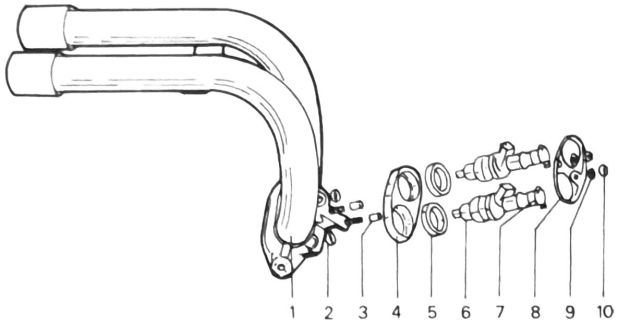


FIG 2:24 The injector and manifold components

Key to Fig 2:24 1 Suction tube with valve seat 2 Inner valve bearing 3 Sleeve 4 Injector valve plate 5 Outer injector valve bearing 6 Electromagnetic injector valve 7 Hose connection with clamp 8 Injector valve retainer 9 Spring washer 10 Nut

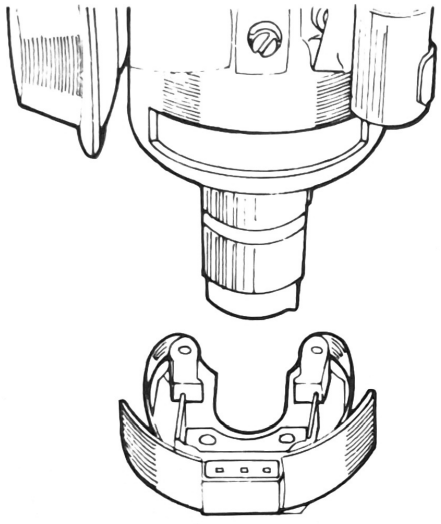


FIG 2:25 The trigger contacts of the distributor

The computer itself is far beyond the scope of this manual but it is a solid-state device using printed circuits. It can be considered as a highly sophisticated switch which turns the fuel on and off at the injectors. The computer has been found reliable in service but if it is thought to be defective, checks must be carried out using special test equipment. The owner should not attempt diagnosis or rectification.

The fuel circuit on its own is shown in **FIG 2:15**. The damper 8 is fitted to quieten the noise of the fuel through the lines. Return lines are fitted to lead back surplus fuel from the pressure regulator valve 4 and from the fuel pump 2. The pump is only operated when the engine is actually running but when the ignition is switched on the pump immediately runs for a short period to pressurize the system ready for starting.

The electrical circuit is shown in **FIG 2:16**. The throttle valve 6 is fitted to shut off the fuel completely on certain conditions of overrun so that the engine acts as a brake and since there is no combustion, emissions are reduced to the minimum. The relays 2 and 3 are fitted to allow components to operate at a heavy current without the full current passing through the computer 4. The operation of the injectors 6 and fuel pump 1 have already been described. The temperature sensor 7 measures the cylinder head temperature and will therefore be quicker in its reactions than the sensor 8 which measures the crankcase temperature. The information from these sensors is fed to the computer so that the quantity of fuel injected can be increased when the engine is cold, making the mixture richer. The pressure sensor 5 is connected to the intake manifold and it measures the absolute pressure so that the computer will automatically compensate for changes in altitude or barometric pressure. The pressure switch 11 measures the difference between intake pressure and atmospheric pressure so that a signal proportional to throttle opening and engine load is sent to the computer. A set of non-adjustable contacts is fitted into the base of an otherwise conventional distributor. The distributor is synchronized with the engine so that the pulse from the contacts will trigger off injection at the correct moment. By integrating the pulses, the computer calculates the engine speed directly. From all these sensors the computer now has the information when to initiate fuel injection and the amount of fuel required.

The air system is shown in **FIG 2:17**. All the air for operation is drawn through the air cleaner 6. A standard throttle valve, operated by the accelerator linkage, is fitted in the air intake distributor 2 to control the air flow and engine speed. At idle, the throttle valve is fully closed and the air for idle passes through the bypass 7 which is used to set the idle speed. An auxiliary air regulator 8 is fitted to supply extra air when the engine is cold, so that the idle speed is increased. A sectioned view of the auxiliary air regulator is shown in **FIG 2:18**. The device is mounted in the crankcase and is purely mechanical in operation. When the engine is very cold, the bi-metallic spring fully opens the port so that maximum air flows through. As the spring warms up it closes the port, reducing the amount of air passing through. When the engine has been standing for some time it will be at ambient temperature and the auxiliary air regulator will then pass the amount of air required for starting at that temperature. When the engine starts and warms up, the bi-metallic spring will warm up with the engine until when the engine is hot the port is fully closed off and no auxiliary air passes through. The computer will have the equivalent information from the temperature sensors and will reduce the amount of fuel injected correspondingly.

2:11 Maintenance

Check that the accelerator linkage operates freely, lubricating the pivot points occasionally. Clean the air cleaner and renew the filter at the correct intervals.

Air cleaner:

An oil bath air cleaner is fitted, as for models with carburetters. The air cleaner must be cleaned out when there is a minimum of 4 to 5 mm (.16 to .2 inches) of oil left above the sludge. In extreme conditions, cleaning may be required daily but under normal conditions check at intervals of 1000 miles until the servicing period can be established which is correct for the use which the car is given.

Pull the crankcase breather hose off from the air cleaner. Disconnect the remainder of the hoses to the air cleaner. Slacken the wing screw and lift the complete air cleaner out, taking care to keep it horizontal.

Free the two clips and remove the upper portion of the air cleaner. **Do not lay this upper portion down on the bench so that the filter element is uppermost.**

Clean out the lower portion of the air cleaner, removing all sludge and old oil. If need be, scrape the upper portion with a piece of wood to clean the holes. Only if the air cleaner has been grossly neglected should it be necessary to swill the filter element portion in paraffin or diesel fuel to clean it.

Fill the lower portion to the mark with fresh oil (approximately .45 Litre .8 pint). Normally SAE.30 oil should be used but SAE.10 oil can be used in arctic conditions. Fit the top portion back into place so that the marks shown in **FIG 2:19** are again in alignment and install the air cleaner in the reverse order of removal.

Fuel filter:

The fuel filter on pre-1970 models should be renewed at intervals of 10,000 km (6000 miles) and on later models at intervals of 20,000 km (12,000 miles). **The filter cannot be cleaned and it must be renewed.**

The method of renewing the filter on earlier models is shown in **FIG 2:20**. Clamp the hoses to prevent fuel from draining out and disconnect them from the filter. Fit a new filter back into place, **making sure that the arrow points towards the pump.** Check for fuel leaks after removing the clamps.

The attachment of the later filters is shown in **FIG 2:21**. In both cases work will be easier if the front of the car is raised off the ground, as the filter is mounted at the front.

2:12 Adjustments

The adjustments that can be carried out by the owner are strictly limited in range. Special test equipment is made for diagnosing faults and making accurate adjustments so in case of difficulty the car should be taken to a suitable VW agent.

Fuel pressure:

An accurate gauge is required. Remove the air cleaner and take out the screw and washer from the righthand side distributor pipe between the righthand injectors. Install the gauge onto the pipe. Start the engine and allow it to run for a short while so that the pressure stabilizes. The correct pressure is 2.0 kg/sq cm (28 lb/sq inch). If the pressure is incorrect, adjust the pressure regulator below the righthand intake manifold. Slacken the locknut **A**, shown in **FIG 2:22**, and adjust the screw **B** to bring the pressure within limits. Tighten the locknut when the adjustment is correct.

Before making adjustments it is advisable to check that the fuel filter is clean and has not been left in for longer than its normal life. Check the fuel pump by connecting an ammeter in series with it and if it is satisfactory it will be taking a current of approximately 2.1-amps.

Idling speed:

A tachometer must be used when adjusting the idling speed as the ear alone is not sufficiently accurate. Connect the tachometer to the ignition circuit and start the engine. Run the engine until the temperatures have stabilized at normal. Adjust the idle speed to the slowest at which the engine continues to run and then increase the speed to 950 + 50 rev/min. If too fast an idle speed is set, slow down the engine to below the correct speed and then gradually adjust it back up until it is within limits.

Throttle valve switch:

The switch and its attachments are shown in **FIG 2:23**. Each graduation on the scale represents 2 deg.

Slacken the mounting screws and turn it in the opposite direction to the arrow. Slowly turn the switch back in the direction of the arrow until a click is heard; note the graduation mark at which this occurs and turn the switch a further graduation in the direction of the arrow. Tighten the screws to secure the switch in this position. Disconnect the return spring and check that the throttle linkage operates freely throughout its range of movement.

Note that on models fitted with automatic transmission a kick-down switch is also fitted.

2:13 Components

In 1970 the pressure switch was combined with the pressure sensor so it will only be found as a separate component on the earlier models.

Fuel injectors:

The injectors are operated in pairs and the pair at the rear are fitted with grey plugs while those at the front are fitted with black plugs. Each side of the engine will therefore have one grey plug and one black plug. The injectors are removed in pairs on the same side of the engine.

A brief test can be carried out on injector performance once they have been removed from the engine but left connected to their fuel lines and leads, with the earth lead grounded. Crank the engine on the starter motor and the injector should spray with a regular cone. The fuel system pressure is not high (as on diesels) but it is still not advisable to allow the spray to hit the skin. If there is no injection or if the spray comes out in a deformed cone, install a new injector.

To remove a pair of injectors from one side, disconnect the cable and earth plugs. Remove the two nuts and withdraw the complete assembly from the engine. **Take great care not to damage or knock the needles in the injectors.** The components are shown in **FIG 2:24**.

Install the injectors in the reverse order of removal, making sure that all seals are in position. Fit the washers and tighten the nuts to a torque of .6 kg m (4.3 lb ft). The grey lead must be connected to the rear injector and the black lead to the front one. Do not forget to connect the earth otherwise the injectors will fail to operate.

Fuel pump:

No repairs can be carried out to the unit if it is defective, and a new pump must be fitted in its place.

Clamp the hoses to prevent the fuel lines from emptying

and then cut the special crimped clips securing hoses in place. Remove the attachment bolts securing the pump and take out the pump.

Install the pump in the reverse order of removal, using worm-driven hose clips to secure the hoses. Remove the clamps and check for fuel leaks. Make sure that the electrical plug is correctly connected.

Distributor contacts:

These are secured in the base of the distributor by two screws, as shown in **FIG 2:25**. The contacts cannot be adjusted and if they are worn a new set must be fitted. Disconnect the plug, remove the two screws and withdraw the old contact set.

Refit the contacts in the reverse order of removal, after lightly greasing the pivot points and cam.

Pressure sensor:

On earlier models, slacken the front pair of screws (on the lefthand side of the engine compartment) but do not remove them. Disconnect the vacuum hose and blank both hose and adaptor on the sensor to prevent the entry of dirt. Disconnect the electrical plug. Remove the rear pair of screws, slide the unit rearwards to free it from the front screws and then remove it.

On the 1970 and onwards models, remove both attachment screws but still make sure that the vacuum hose and adaptor are blanked off.

Pressure switch (pre-1970 models only):

This is fitted under the righthand side manifold pipes and is secured to them by a nut and bolt. A narrow 10 mm socket spanner and extension will be required to remove the nut and bolt.

Take out the unit and disconnect the plug, after disconnecting the vacuum hose.

Connect the plug to the unit before fitting the unit. If the switch touches the manifold pipes after installation, fit a spacer washer to make sure that the unit is clear of the pipes. Reconnect the vacuum hose.

Temperature sensors:

The cylinder head sensor is fitted to the lefthand cylinder head. Disconnect the lead and then use an open-ended spanner to undo the nut. Withdraw the sensor when the nut is free. Do not overtighten the nut when installing the cylinder head sensor.

The crankcase sensor is attached to the auxiliary air regulator.

Detach the lead from the sensor and then unscrew the sensor from the auxiliary air valve. Disconnect the hoses to the auxiliary air regulator, after labelling them, and blank them off to prevent the entry of dirt. Take out the attachment and remove the air regulator, plugging the orifice to prevent the entry of dirt.

When installing the parts, tighten the attachment screw to a torque of 1.5 kg m (11 lb ft).

2:14 Fault diagnosis

(a) Engine will not start

1 Fuel pump not operating
2 Pressure sensor disconnected or defective (causes very rich mixture)
3 Temperature sensors disconnected or defective
4 Insufficient fuel pressure
5 Kinked or blocked fuel lines
6 Trigger contacts defective or disconnected
7 Defective lead between starter motor solenoid and computer

(b) Engine starts then stalls

1 Check 6 in (a)
2 Blocked fuel tank vent

(c) Misfiring (ignition satisfactory)

1 Dirty or defective trigger contacts*
2 Loose connections*
3 Defective injector (exhaust shows white smoke)
4 Poor injector earthing (usually cuts injectors in pairs)
*Engine may stop after a period of misfiring.

(d) Lack of power

1 Check 3 and 4 in (c)
2 Pressure switch disconnected or defective (combined unit on later models)

(e) High fuel consumption

1 Temperature sensors defective or loose connections to them
2 Mechanical faults on car (binding brakes, low tyre pressures, clutch slip)

(f) Engine hunts excessively while running in low range

1 Hose between auxiliary air regulator and air distributor disconnected

CHAPTER 3

THE IGNITION SYSTEM

3:1 Description

A schematic diagram of the ignition circuit is shown in **FIG 3:1**. The distributor is mounted on the engine and driven at half engine speed, and is synchronized with the engine. The distributor shaft carries a four-lobed cam which operates the contact points and the rotor arm is mounted on top of the distributor shaft.

When the contact points are closed, a low-voltage current flows through the primary circuit of the ignition, setting up a magnetic field around the primary windings in the ignition coil. When the contacts open, at the correct instant under the action of the cam on the shaft, the current is rapidly cut off (assisted by the action of the capacitor) and the magnetic field in the ignition coil collapses rapidly. The collapse of the magnetic field induces a very high voltage in the secondary windings of the ignition coil. This high voltage is led to the centre electrode of the distributor cap. A carbon brush leads the high-voltage from the centre electrode to the rotor arm. The rotor arm, being correctly set, guides the high-voltage to the correct side electrode in the cap from where it is led to the sparking plug of the correct cylinder. The voltage jumping across the electrodes of the sparking plug ignites the mixture in the cylinder.

The actual instant of firing is dependent on the engine speed and the mixture in the cylinder. Combustion is not instantaneous but spreads as a wave front through the mixture, and the rate of propagation of this wave front depends on the mixture strength. The ignition must be initiated at the correct instant to ensure that maximum pressure is being exerted on the pinion as it is travelling downwards.

The distributor shaft is fitted with two spring-loaded weights which move outwards under centrifugal force. As the engine speeds up, the weights move outwards and turn the cam portion of the shaft forward in relation to the remainder of the shaft, this action advancing the ignition point with increase in engine speed.

The suction in the inlet manifold is proportional to the throttle opening and load on the engine. A small bore vacuum tube connects the manifold to the vacuum unit of the distributor. A diaphragm is acted on by the vacuum and this diaphragm rotates the contact breaker plate in the distributor body to advance the ignition as required.

3:2 Maintenance

The HT leads, distributor cap and ignition coil top should be kept free of oil, dirt or moisture at all times. A

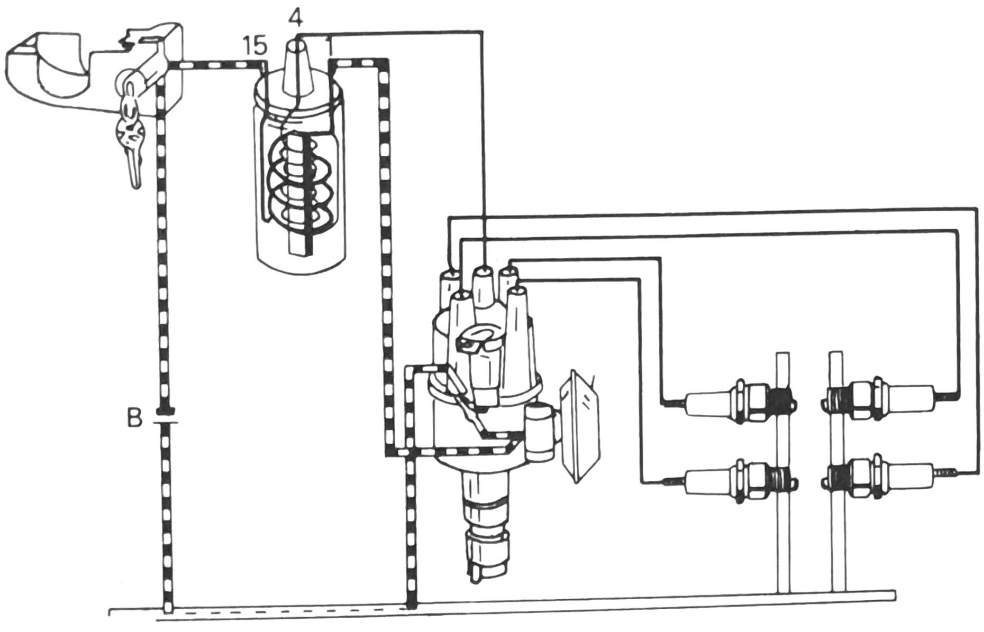


FIG 3:1 A schematic diagram of the ignition system

regular wiping over the outside of the parts with a soft clean cloth will keep them clean and ensure that no leakage paths can build up.

The sparking plugs should be cleaned at intervals of 8000 km (6000 miles) and renewed at intervals of 16,000 km (12,000 miles). The electrodes wear and deposits build up deep inside the plug which cannot be removed by cleaning and it is for this reason that the plugs should be renewed regularly. Some of these deposits only conduct when hot and therefore the effect will not show up when pressure-testing the plugs. Full details of sparking plug maintenance are given in **Section 3:7.**

Lubrication:

The distributor should be lightly lubricated at intervals of 6000 miles. Typical distributor components are shown in **FIG 3:2**. Free the clips 9 and lift off the distributor cap 2. Firmly but squarely pull off the rotor arm 3. A typical distributor will then appear as shown in **FIG 3:3**. Inject a few drops of oil through the hole arrowed and with a clean finger smear a little grease around the lobes of the cam. If a lubricator is fitted for the lower bush, add a few drops of oil through it. Pour a few drops of oil onto the felt pad exposed after the removal of the rotor arm. Check that the moving contact pivots freely about its pivot post and occasionally add a single drop of non-creeping oil to the pivot post (Ragosine Listate).

Take great care not to overlubricate or to allow any lubricant onto the contacts themselves. Wipe away all surplus lubricant. The aim is to lubricate lightly and regularly.

Distributor cap and rotor arm:

Wiping down all over with a clean soft cloth is usually sufficient cleansing, but if there is excessive oil or dirt use a small stiff brush and chloroform or methylated spirits (denatured alchohol). Check the parts for cracks or signs of 'tracking' in the cap. Tracking shows up as thin black lines between electrodes or an electrode and the edge of the cap. If a defect is found, the part must be renewed otherwise it can be a cause of persistent misfiring.

Cleaning contact points:

In normal use metal will be transferred from one contact to the other, forming a crater on one and a pit in the other. This build-up of metal will not affect performance until it has reached the normal gap of the contacts and the contacts should then be renewed. In an emergency they can be cleaned by grinding or using a special file.

Normally the contacts should only require cleaning if they are contaminated with oil or grease. The contacts should have a slate-grey frosted appearance for optimum efficiency but lubricant will blacken them. Contamination will also show up as a smudgy line of black on the base-plate under the contacts. Clean using a small stiff brush with chloroform or methylated spirits as a solvent.

Renewing contact points:

The points must be renewed when the build-up of metal exceeds the correct gap, also if they are excessively burnt or it is no longer possible to set the correct dwell and gap.

Remove the distributor cap and rotor arm. There are slight differences in the construction of various distributors but these general instructions will cope with all types. **Check the position of all insulating washers as parts are removed and make sure that they are correctly refitted.** Free the spring end of the moving contact from its terminal, noting that if the spring is secured to the terminal on the side of the distributor body the spring will be slotted so that it can be pulled out after

slackening the attachment. If necessary, remove the spring clip securing the contact to the pivot post and slide the moving contact up and off. Remove the securing screw for the fixed contact and take out the contact, noting the positions of insulating washers.

New contacts are installed in the reverse order of removal, after washing them in methylated spirits to remove any protective. Adjust the gap after the contacts are fitted.

Check that the moving contact pivots freely about its post and that the spring has not weakened with use. If the contact sticks, remove it and lightly polish the post with fine emerycloth, lubricating it with a single drop of oil before installing the moving contact.

Adjusting the points:

The most satisfactory method is to use a dwell meter but this should be left to an agent as a special meter is required.

The gap can also be set using feeler gauges, though if this is done on used points care must be taken to insert the feeler gauge only between the unworn portions of the contacts.

Remove the distributor cap and rotor arm. Crank the engine by hand until the foot of the moving contact is on the lobe of the cam and the points are at their widest gap. Three differing types of adjustment are shown in **FIG 3:4**. Slacken the fixed contact hold-down screw **A** slightly so that the fixed contact can be moved but does not move under its own weight. Fit the blade of a screwdriver to **B** and by turning the screwdriver alter the contact gap. Slide a clean feeler gauge between the unworn portions of the contacts and adjust the gap until slight drag is felt on the feeler gauge. Tighten the securing screw and check that the gap has not altered. Crank the engine over and check the gap at the other three lobes of the cam. The correct gap is .4 mm (.016 inch).

Install the rotor arm and distributor cap.

3:3 Ignition faults

Before carrying out checks on the ignition system make sure that the symptoms are not caused by a defective fuel system. Check the points in the distributor and make sure that they are clean and correctly set. It is also worthwhile to check that the ignition timing is correct. Note that a persistent misfire can be caused by an engine defect, such as a sticking valve.

If the engine has a persistent misfire and the fault is traced to the ignition circuit, start the engine and run it until it has reached its normal operating temperature. Clip the throttle open to give a fast-idle speed. Disconnect each HT lead from its sparking plug in turn. **Do not use the bare hands in case the lead is defective but use rags or a thick glove as insulation.** If the rough running or misfire becomes more pronounced when an HT lead is disconnected then that cylinder is satisfactory. If there is no difference in the running of the engine when a lead is disconnected then that cylinder is not firing for some reason.

Having identified the faulty cylinder, stop the engine and fit an old sparking plug or piece of rod into the moulded HT lead connector. Start the engine and hold the lead so that the end is approximately 5 mm ($\frac{3}{16}$ inch) away from a grounded metal part of the engine or car.

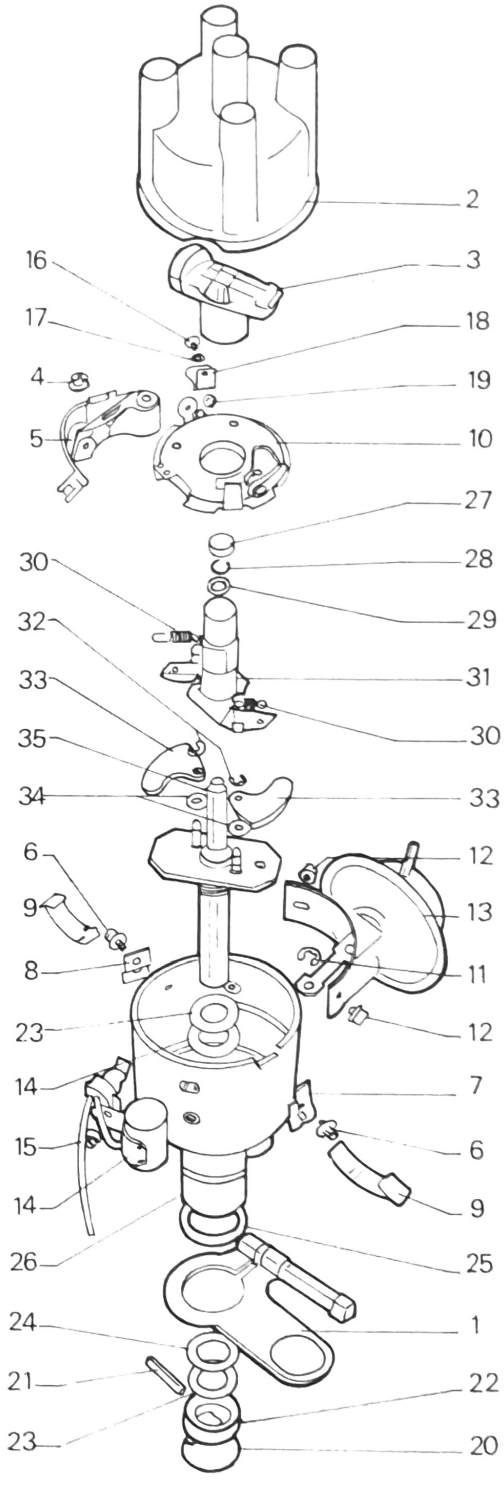


FIG 3:2 Typical distributor components

Key to Fig 3:2 1 Distributor clamp bracket 2 Distributor cap 3 Distributor rotor 4 Contact securing screw 5 Contact breakers 6 Screw 7 Securing tab 8 Securing tab 9 Retaining clip 10 Breaker plate 11 Pullrod securing clip 12 Screw 13 Vacuum unit 14 Condenser 15 Screw 16 Screw 17 Spring washer 18 Ball retaining spring 19 Ball 20 Circlip 21 Securing pin 22 Driving dog 23 Shim 24 Fibre washer 25 Rubber sealing ring 26 Distributor body 27 Felt washer 28 Circlip 29 Thrust ring 30 Return spring 31 Distributor cam 32 Circlip 33 Flyweight 34 Washer 35 Drive shaft

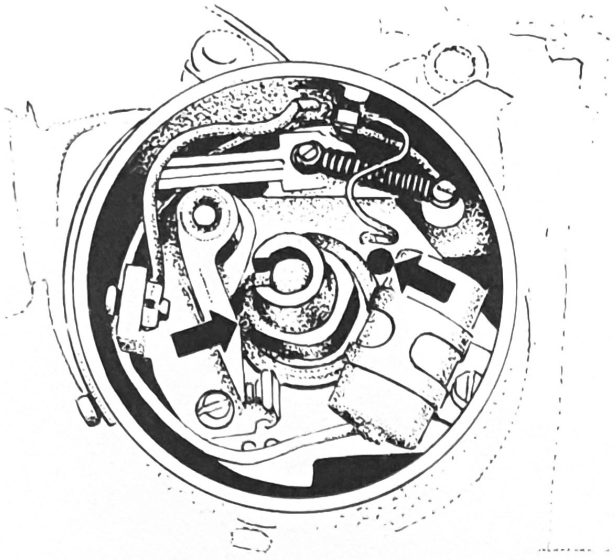


FIG 3:3 Lubricating the distributor

Do not hold the lead near the fuel system because of the danger of fire. If the ignition system is satisfactory there will be a series of fat blue sparks jumping across. If the sparks are satisfactory, remove the sparking plug and either have it cleaned and tested or install a new one in its place. If the fault persists then the defect lies in the engine.

If the sparks are weak, irregular, and reddish in colour check the HT lead for signs of perishing, burn marks, or other defect. If the lead appears at all defective, renew it and repeat the test. If renewal of the lead fails to bring any improvement, check the distributor cap and rotor arm for cracks, dirt, or tracking, as well as making sure that the carbon brush in the cap is satisfactory.

If all leads give poor sparks, disconnect the main HT lead between the ignition coil and distributor, crank the engine over on the starter motor and check that there is a regular fast stream of good sparks between the end of the lead and a good ground. If the sparks are weak or irregular, the ignition coil or its HT lead is defective.

Testing the low-tension circuit:

As a quick check, remove the distributor cap and crank the engine until the contact points are closed. Switch on the ignition and flick the contact points apart with a fingernail. If current is flowing there will be a small low-voltage spark across the contacts. If the central HT lead is held 5 mm from a grounded metal part there should be a good spark every time that the contacts are flicked apart.

A better test is to disconnect the low-tension lead between the distributor and ignition coil and then reconnect it with a test lamp in series. Slowly crank the engine over while watching the test lamp. Preferably remove the distributor cap so that the action of the points can be observed and there is no danger of the engine actually starting. When the points are closed the lamp should be lit and the lamp should go out as the points open.

If the lamp stays on continuously, there is a shortcircuit in the distributor. Check for correct assembly of all insulating washers and check that the leads are correctly connected and that their insulation is not frayed or damaged. If the distributor is satisfactory, repeat the test with the capacitor disconnected.

If the lamp does not light at all, check that the points are closing and that they are not excessively dirty. Use the test lamp to trace back through the wiring until the fault is found and can be rectified.

Capacitor:

On some models the capacitor is mounted externally on the distributor but on others it is mounted internally.

Shortcircuits in the distributor are usually self-healing, as the spark erodes away the metal foil in the area of the short. A shortcircuit is easily found using a test lamp as described just previously.

An open-circuit failure is more difficult to detect without special test equipment but it should be suspected if starting is difficult and the points are excessively blued or burnt. Note that capacitor failure is fairly rare so check for other faults before renewing the capacitor.

3:4 Distributor removal and installation

Distributor:

The cylinder numbering sequence, firing order, and correct position of the lead to No. 1 electrode on the cap are shown in **FIG 3:5**.

Remove the distributor cap and note the position of the rotor arm in the distributor. Free the attachments securing the clamp plate to the engine and withdraw the distributor after disconnecting the vacuum line and primary lead.

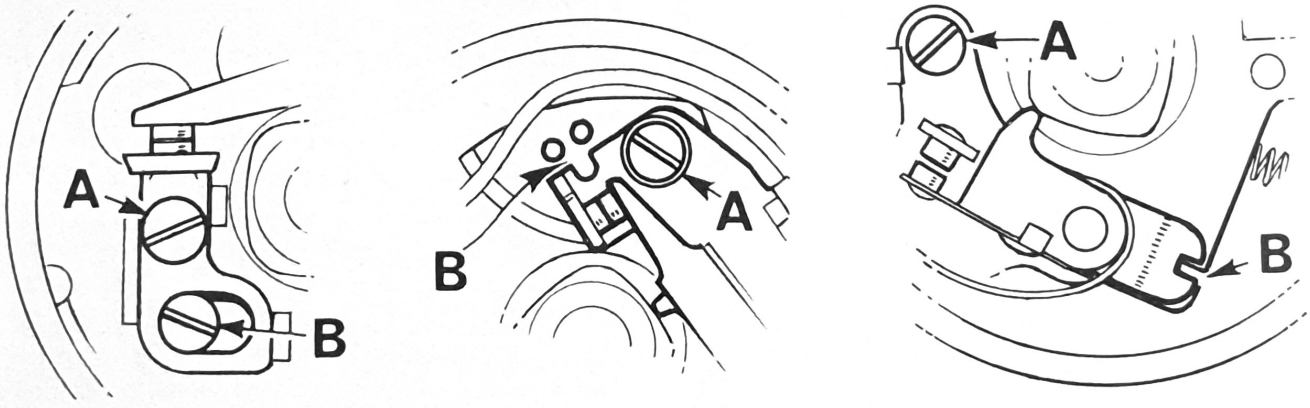
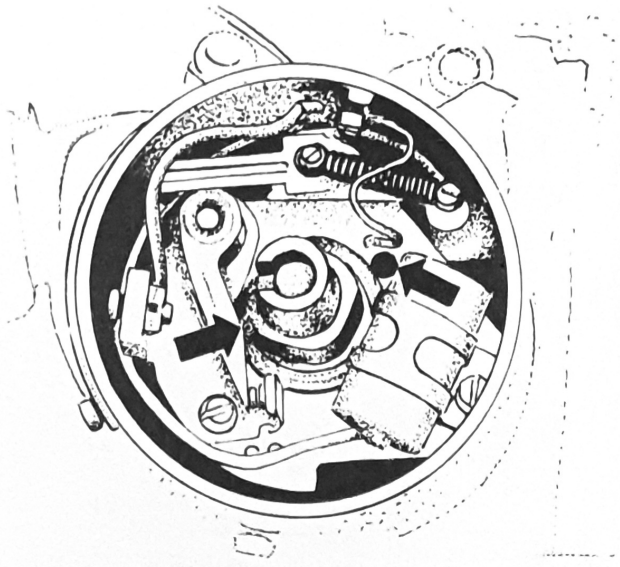


FIG 3:4 Various methods of adjusting the contact gap



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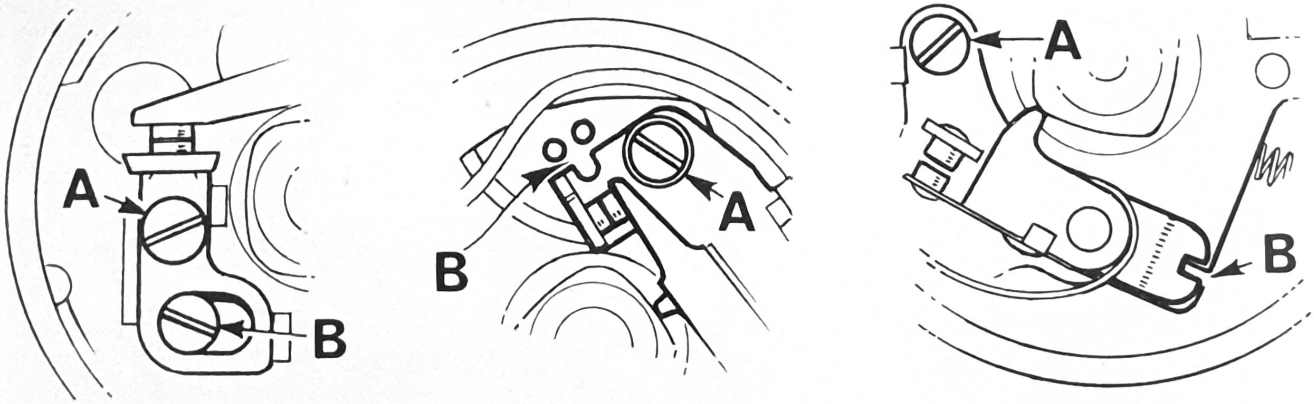
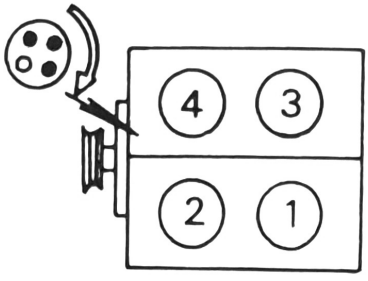


FIG 3:4 Various methods of adjusting the contact gap



1-4-3-2

FIG 3:5 The cylinder numbering sequence and firing order

Do not slacken the pinch bolt securing the clamp plate to the distributor. Provided that the engine is not cranked while the distributor is out, the distributor can be installed in the reverse order of removal without losing the timing. Note that the drive dog on the end of the distributor shaft has an offset on it so that it will only fit in one position.

If the engine is to be cranked or otherwise worked on, set it to TDC on No. 1 cylinder before removing the distributor. The TDC point is found from the timing marks on the cooling fan and the firing position is found by observing the valves (with the rocker cover off) or blocking the spark plug hole with a finger. Both valves will be fully closed at the firing TDC or a pressure rise will be felt in the cylinder as the engine is cranked while the piston rises on the compression stroke. Some distributors will have a dot or mark on the body, as shown in **FIG 3:6**, indicating the position of the rotor arm at the firing point of No. 1 cylinder. After the engine has been cranked, return it to the correct position and then install the distributor in the reverse order of removal.

Distributor drive:

Remove the distributor as described earlier. Lift out the spacer spring from the shaft. A typical shaft is shown in **FIG 3:7**. The shaft can now be withdrawn from the engine. Preferably use the special tool VW.228B inserted into the top of the shaft, but a piece of wood, sharpened

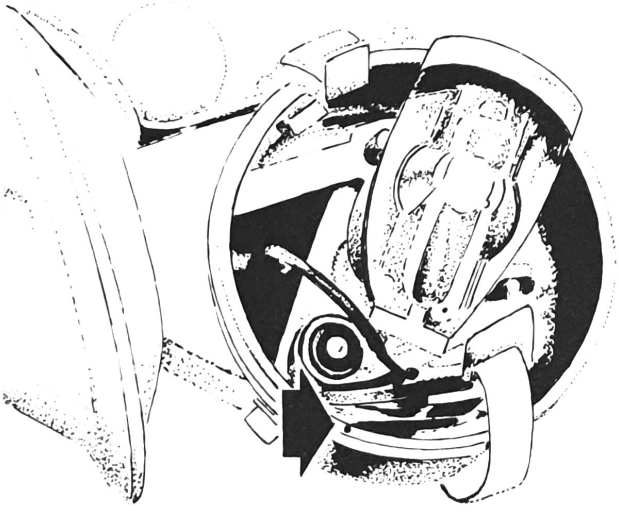


FIG 3:6 Timing mark on distributor case

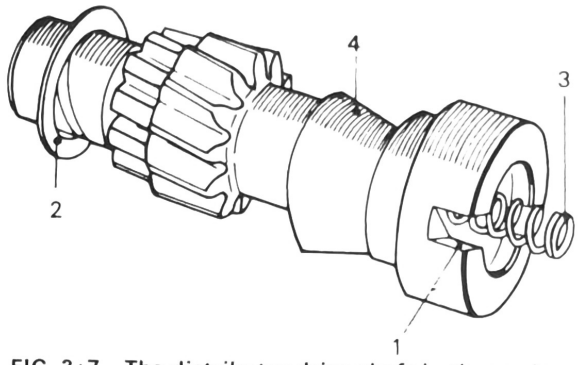


FIG 3:7 The distributor drive shaft in the engine

Key to Fig 3:7 1 Offset drive 2 Thrust washer 3 Spring 4 Fuel pump drive eccentric

to a suitable taper and pressed firmly in, can be used instead. The shaft will rotate slightly as it is withdrawn. The thrust washer will most probably remain in the crankcase. Withdraw the thrust washers preferably using a magnetized rod but a wire hook can be used. **Take great care not to allow the thrust washer to drop down into the engine.**

Clean the parts and check for wear or damage. Pay particular attention to the condition of the thrust washers and the gear teeth. If the gear on the drive shaft is worn it is likely that the mating gear in the engine is also worn.

Refit the thrust washer, taking great care not to drop it (or them) into the crankcase. Slide them down into place using a suitable piece of rod and make sure that they stay in place by smearing them with thick grease.

Set No. 1 cylinder to the firing position. Hold the drive shaft above the engine so that the slot is positioned as shown in **FIG 3:8**, with the smaller segment outwards. Rotate the shaft to allow for the meshing and lower it down into position so that it ends up as shown in the figure. Install the spacer spring and refit the distributor.

3:5 Servicing the distributor

Typical distributor components are shown in **FIG 3:2**. It should be noted that VW run an excellent exchange scheme and if the distributor is excessively worn it will be far more satisfactory to exchange it rather than to try

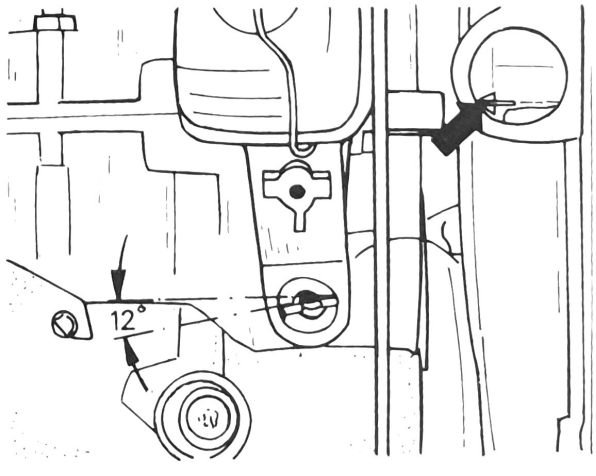


FIG 3:8 The distributor drive shaft correctly installed

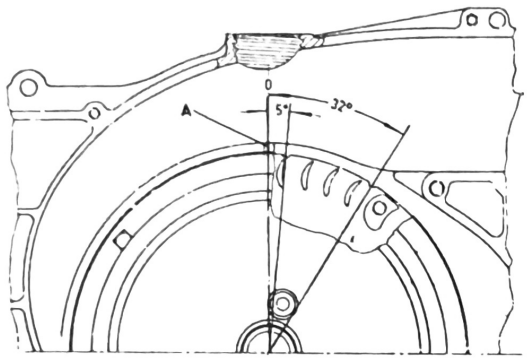


FIG 3:9 Typical ignition timing marks

to repair. Difficulty may also be found in obtaining items such as shafts, bushes etc.

The models fitted to cars with fuel injection systems have trigger contacts installed in the base. These contacts are non-adjustable and must be renewed when defective (see **Chapter 2, Part 2**).

The adjustment and renewal of the contact points is dealt with in **Section 3:2** and the capacitor in **Section 3:3**.

Vacuum unit:

This is a sealed unit and must be renewed if it is defective. Disconnect the link of the unit from the baseplate and also disconnect the vacuum line. Remove the screw securing the unit to the side of the case and withdraw it from the distributor. Refit in the reverse order of removal.

The vacuum unit can be checked by pressing in the link and blocking the vacuum connection with a finger. Release the link and suction should be felt. If there is no suction, or it drops rapidly, the diaphragm is punctured and the vacuum unit must be renewed.

Baseplate:

Remove the contact points and capacitor. Take out the screws that secure the baseplate assembly and lift it out of the distributor. On some models, the screws securing the baseplate will also secure the clips that hold on the distributor cap.

Cam and weights:

Remove the baseplate assembly. Carefully free the return springs from between the weights and cam. **Take great care not to distort or stretch these springs as they control the amount of advance.** One spring may be longer than the other but it has been designed so and is not necessarily defective. Note the relation of the slot for the rotor arm in relation to the offset of the drive dog, as this must be correct on reassembly. Free the clips so that the cam and weights can be removed.

Lubricate the parts lightly with oil after cleaning them and reassemble them in the reverse order of dismantling. The indented faces on the weights are fitted uppermost.

Shaft assembly:

If there is excessive wear, install a new or reconditioned distributor as it will be difficult to obtain spares. The shaft can be removed, after taking off the cam assembly, by driving out the pin and removing the drive dog.

3:6 Setting the ignition timing

The timing should be set statically first and then checked with the engine running, using a stroboscopic light. On models fitted with carburetters, the static setting is sufficiently accurate but on models fitted with fuel injection a stroboscopic light must be used afterwards.

Typical timing marks are shown in **FIG 3:9**. Note that there may be variations.

Crank the engine until No. 1 piston is at TDC on the firing stroke, using the alternator belt. Set the engine so that the black mark on the fan is in line with the notch on the fan housing. Disconnect the primary lead from between the distributor and ignition coil and reconnect it with a test lamp in series. Slacken the pinch bolt securing the distributor in the clamp. Switch on the ignition and gently turn the distributor body in either direction until the point is found where the test lamp just goes out, indicating that the contacts have just opened. Tighten the pinch bolt without allowing the distributor body to rotate.

Crank the engine over for two full revolutions, slowing down the rate of turning towards the end of the second revolution. Stop turning the instant that the test lamp goes out. If the timing is correct, the timing marks will again be in alignment.

Stroboscopic method:

Set the static ignition timing. Start the engine and run it until it has reached its normal operating temperature. Stop the engine and connect the stroboscopic lamp as instructed by the makers of the instrument. Set the lamp so that it will shine down onto the timing marks. Slacken the pinch bolt on the distributor slightly and disconnect the vacuum line from the distributor.

Start the engine and clip open the throttle so that the engine is running at a speed of 3500 rev/min. Rotate the distributor body until the red timing mark (32 deg. BTDC) appears in line with the notch in the fan housing. Tighten the distributor pinch bolt and check that the timing has not altered.

3:7 The sparking plugs

Removal:

Slacken the sparking plug using a well fitting box spanner or suitable plug spanner. Use an air line or tyre pump to blow away all loose dirt from around the base of the plug. Fully unscrew the plug, without the aid of leverage on the box spanner. Once the plugs have been removed, store them in order for later examination of the firing ends.

If the plug is stiff, work it in and out as far as possible, gradually unscrewing it further as the threads free. If the plug is very stiff, wrap a piece of rag around the base and soak it with penetrating oil, paraffin, or suitable solvent and leave it overnight before attempting to remove it.

Examination:

The colour and condition of the deposits on the firing ends of the sparking plugs will give a good guide to the conditions inside the combustion chambers. After

examining the plugs, throw away any that have badly burnt electrodes or cracked insulators without bothering to have them cleaned or checked.

A light powdery deposit ranging in colour from brown to greyish tan, coupled with light wear on the electrodes, indicates that the conditions are normal. Much city or constant-speed driving will leave the deposits white or yellowish but again this is satisfactory. Such plugs need only cleaning and testing.

If the deposits are wet and black, they are caused by excessive oil entering the combustion chamber (either past worn valve guides and stems or past worn piston rings and bores). Fitting a hotter-running grade of plug may help to alleviate the problem but the only cure is an engine overhaul.

If the deposits are black but dry and fluffy they are caused by incomplete combustion. Excessive idling or incorrectly adjusted fuel system will cause all the plugs to have such deposits. Individual plugs may be defective or there may be a fault in the ignition.

Overheated sparking plugs have a white blistered look about the central insulator and the electrodes will be excessively burnt. If lead-based fuels are used, glints of metal may be seen on the central insulator and electrode. Some possible causes are engine overheating, very weak mixture, incorrectly set ignition timing (or using a very low grade fuel), incorrect grade of plug, or running at high speeds with the car overloaded.

Cleaning, adjusting and testing:

Wash oily sparking plugs in fuel or methylated spirits as oil will cause the abrasive to stick and prevent cleaning. Have the sparking plugs cleaned on an abrasive-blasting machine and then tested under pressure after attention to the electrodes.

Trim the electrodes square with a fine file and adjust them to the correct gap of .7 mm (.028 inch) by bending the side electrode. **Do not bend the central electrode otherwise the insulator will crack.**

In an emergency, the plugs can be cleaned by scrubbing them with a steel-wire brush, though this method is not so effective.

Clean the external portion of the insulator using some suitable harsh solvent. If the threads have not been effectively cleaned by the abrasive-blaster, scrub them with a wire brush so that there are no carbon deposits left.

Installation:

If the threads in the cylinder head are dirty, clean them using a well greased tap. Failing a tap of the correct size, use an old sparking plug with crosscuts down the threads.

Use only graphite grease on the sparking plug threads as any other grease will bake hard with use and lock the plug in place.

Check the sealing gaskets and renew them if they are compressed to less than half their original thickness. Screw the plugs in by hand until they bottom and then tighten them with a torque spanner to a load of 3 to 3.5 kg m (21 to 25 lb ft). If a torque spanner is not available, tighten them by a maximum of half-a-turn from the hand tight position. Great care must be taken not to strip the threads or cross-thread the plug as it is installed, so any stiffness must be investigated immediately. If the threads are stripped, the cylinder head must be removed and Heli-Coil inserts fitted.

3:8 Fault diagnosis

(a) Engine will not start

1 Battery low or discharged, dirty or loose connectors
2 Distributor points dirty or out of adjustment
3 Distributor cap dirty, wet, cracked, or tracking
4 Carbon brush in distributor cap defective
5 Defective low-tension circuit
6 Rotor arm cracked
7 Broken contact breaker spring
8 Contacts stuck open
9 Water on HT leads
10 Defective ignition coil
11 Defective capacitor
12 Rotor arm omitted on reassembly

(b) Engine misfires

1 Check 2, 3, 5 and 10 in (a)
2 Weak contact breaker spring
3 Defective HT lead
4 Sparking plug defective, fouled, loose, or incorrectly set
5 Ignition too far advanced

NOTES

CHAPTER 4

THE COOLING SYSTEM

4:1 Description

The engine is aircooled and therefore many of the parts required for a watercooled engine are not required. This not only simplifies the system but reduces cold weather precautions to a minimum. The car can be left out in the coldest weather without any danger of coolant freezing and damaging the engine. There is the disadvantage that the thickness of material around the cylinders is reduced and therefore the engine will sound noisier than a conventional one.

The components of the cooling system are shown in **FIG 4:1**. The cooling fan 11 is mounted on the engine crankshaft and draws cold air in from outside the car. The action of the fan blows air outwards and the fan housing ducts the air so that it blows over the cylinders and cylinder heads. Baffles are fitted to ensure that all four cylinders are evenly cooled.

The two outlets of the fan front housing are fitted with thermostatically controlled flap valves. The thermostat 55 senses the temperature of the air coming from the engine and controls the flaps. This ensures that when the engine is cold, the flaps are closed and the cooling air flow is restricted. The engine warms up rapidly with the flaps opening progressively to ensure that the engine does not overheat. The thermostat is designed to 'fail-safe' so that if it is defective the flaps will be left open continuously. This ensures that the engine will not overheat but it does mean that the engine will take a long time to reach its normal operating temperature.

The heating system is shown in **FIG 4:2**. Air is blown through the heat exchangers on the engine exhaust pipes and it then passes through a fuel-fired heater before entering the car. An optional time switch can be fitted which switches on the fuel-fired heater and runs it for 10 minutes at a pre-set time. This gasoline-fired heater can be used at any time, even with the engine not running, but because of the drain on the battery running time is limited to 10 minutes.

One drive belt is fitted and this drives the alternator only, as there is no water pump and the fan is attached to the crankshaft.

4:2 Heater

If there are faults in the fuel-fired heater the owner should not attempt to service or repair the unit but should take the car to a VW agent. A safety switch, shown in **FIG 4:3**, is mounted in the engine compartment. If the heater fails, leave it for three minutes and then pull the lever

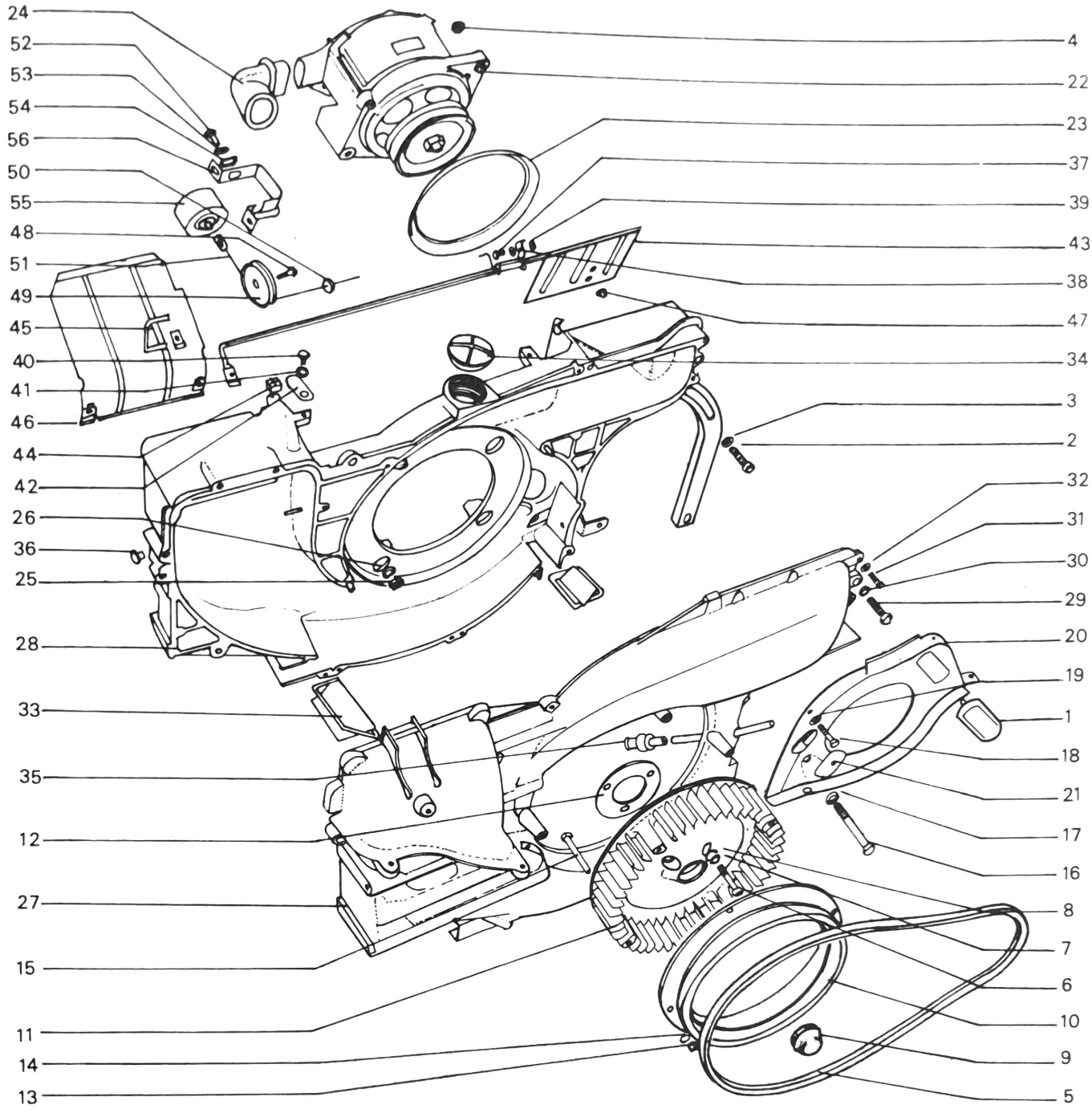


FIG 4:1 The components of the engine cooling system

Key to Fig 4:1 1 Coverplate insert 2 Socket head screw 3 Spring washer 4 Hexagon nut 5 Belt 6 Socket head screw 7 Spring washer 8 Flat washer 9 Cap 10 Crankshaft pulley 11 Fan 12 Spacer 13 Square nut 14 Spring washer 15 Socket head screw 16 Hexagon head bolt 17 Spring washer 18 Cheese head screw 19 Spring washer 20 Coverplate 21 Dipstick grommet 22 Alternator 23 Sealing ring 24 Elbow 25 Nut 26 Spring washer 27 Rear half of fan housing 28 Front half of fan housing 29 Bolt 30 Spring washer 31 Cheese head screw 32 Spring washer 3 Air non-return flap 34 Inspection hole cover 35 Boot for dipstick 36 Plug 37 Bolt 38 Washer 39 Square nut 40 Cheese head screw 41 Spring washer 42 Shaft retaining spring 43 Righthand flap with shaft 44 Bearing 45 Flap link 46 Lefthand flap 47 Plug 48 Hexagon head bolt 49 Roller for cooling air cable 50 Sealing washer 51 Cooling air control cable 52 Hexagon head bolt 53 Washer 54 Washer for thermostat 55 Thermostat 56 Thermostat bracket

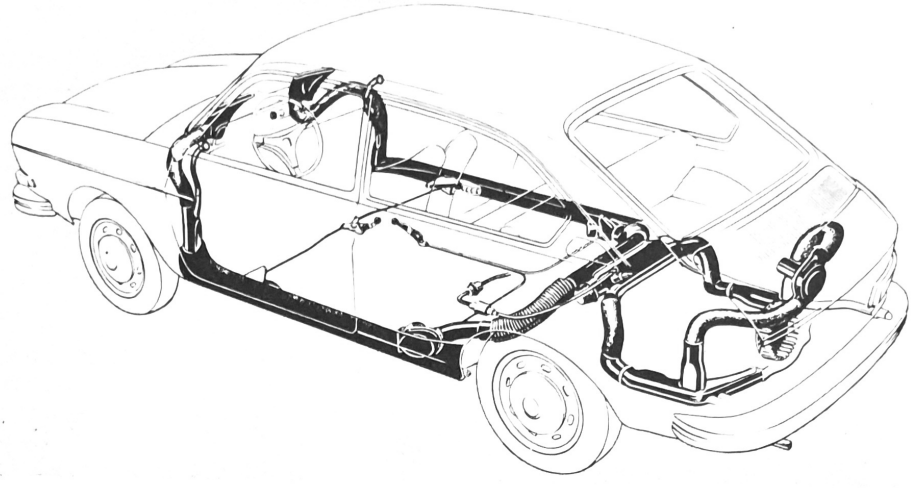


FIG 4:2 The layout of the interior heating system

arrowed to the rear and release it again. If the heater still fails to operate or if it cuts out again within a short period there is a defect and the car should be taken to a VW agent.

Levers on the floor between the front seats control the distribution of the air between footwells and car and further levers on the facia control the air distribution between vents and windscreen.

A rotary knob controls the operation of the fuel-fired heater. Turning the knob to the right turns on the heater and further movement progressively controls the amount of heat produced. The warning lamp which lights when the heater is actually operating is connected into the circuit so that it dims when the parking lights or headlamps are on. It should be noted that when the heater is switched off the lamp will go out but the fan will continue to run for a short period to cool the heater.

The heater may be used without running the engine, but an internal clockwork timer will shut it off after approximately 10 minutes running, to avoid undue drain on the battery.

In summer or warm climates, the heater should be run for at least 10 minutes every 2 months. This ensures that the unit is purged so that there is no build-up of gum.

When refuelling the car, switch off the heater. There is no need to wait until the fan run-down has ceased but the operating light must be off.

4:3 Winter precautions

No special precautions are needed on the cooling system itself, apart from checking that the thermostatically controlled flaps are operating correctly. However this does not mean that antifreeze can be forgotten utterly.

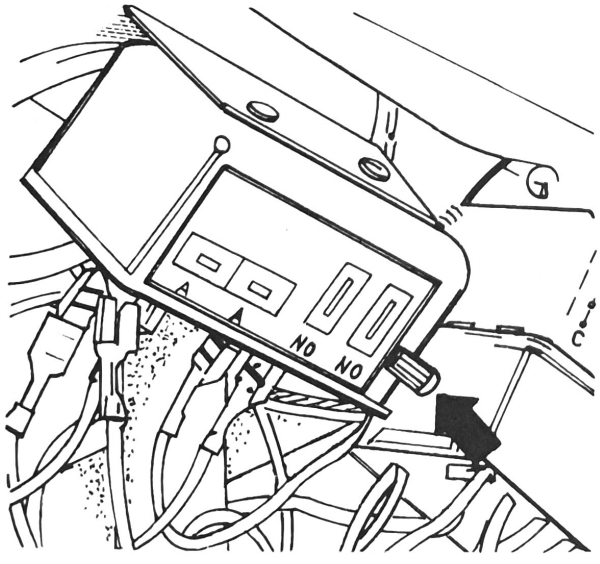


FIG 4:3 The safety switch for the fuel fired heater unit

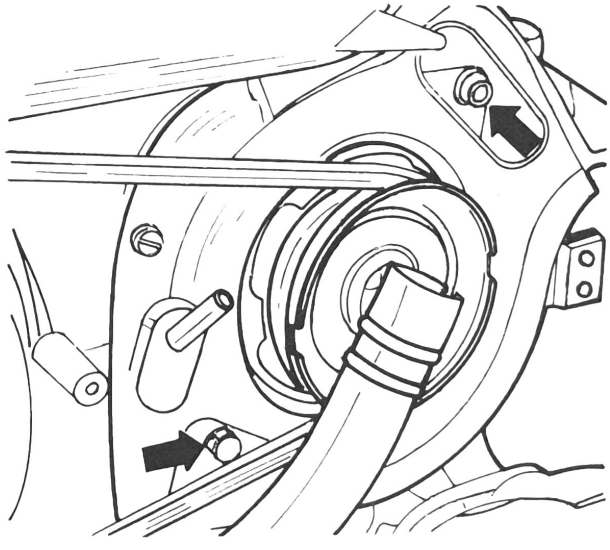


FIG 4:4 The adjustment points for the alternator drive belt

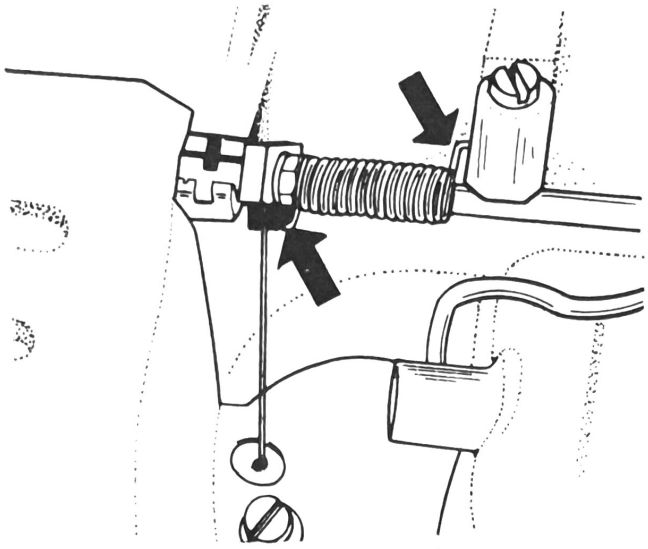


FIG 4:5 The correct installation of the thermostatically controlled linkage retaining spring

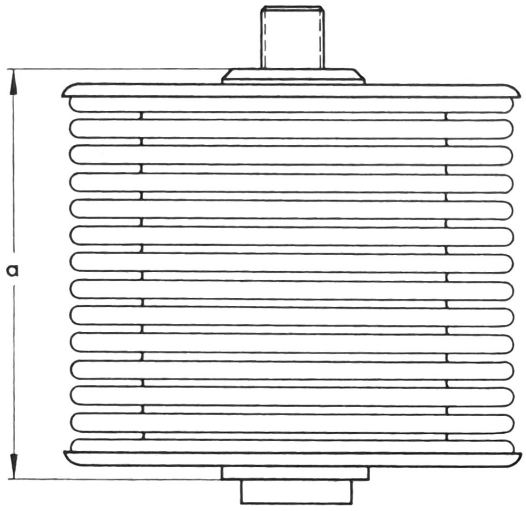


FIG 4:6 Checking the thermostat expansion

The screen washer is filled with water and if precautions are not taken this will freeze up in cold weather. Even worse, it may be just cold enough for the windscreen to be ice cold without the washer water having frozen and in these conditions, use of the screen washer produces a film of instant ice on the windscreen which will only melt when the car has warmed up.

Proprietary special antifreeze compounds are made for screen washers. If these are not available, a mixture of one part methylated spirits (denatured alchohol) to three parts of water will protect against freezing down to a temperature of —12°C (+10°F). Do not use antifreeze which is for use in watercooled engines, as this will leave the glass very smeared.

If the car is used after heavy snow falls, clear away snow from the air intake grilles below the windscreen and rear window so that the ventilation system and air cooling are not obstructed. While clearing the snow, also clear the grilles at the rear end of the body sides as these allow stale air to pass out from the car.

Additional precautions:

These are not connected with the cooling system but it is convenient to list them all under one heading.

For cold weather it is advisable to use a thinner grade oil in the engine so that it starts more easily. The various grades recommended are in **Chapter 1, Section 1:3**. In arctic climates the transmission oil may be changed from SAE.90 to SAE.80, to reduce the drag in the transmission, but this only applies to arctic conditions and need not be carried out normally.

Winter tyres may be used in conditions of ice and snow and the fitting of studded tyres will ensure grip under practically all conditions. If chains are fitted, make sure that they do not stand proud of the tyre wall by more than .6 inch (15 mm) at any point. If chains are fitted to the front wheels as well, though this should very rarely be needed, do not turn the steering to full lock in case the chains foul on the chassis.

The only other point to remember is the battery, which loses efficiency when cold and at the same time has greater demands made on it. A monthly boost on a trickle charger will ensure that it is at full capacity. The battery is inside the car and therefore partially protected from extremes of temperature but in extremely cold climates it will be found that starting is easier if the battery is removed and stored in a warm room overnight.

When the engine has started, drive off. Do not try to warm the engine by running it at idle. While the engine is cold do not race it but otherwise drive the car normally for the least wear and most rapid warm-up.

4:4 Alternator belt tension

The belt tension is correct when it can be depressed by approximately .6 inch (15 mm) at the centre of its run when firm thumb pressure is applied.

If the belt is too tight it will cause damage to the alternator bearings and if it is too slack it will allow the alternator to slip and not produce its full output. At the same time as checking the tension, make sure that the belt is not fraying or greasy. Slight amounts of oil or grease can be removed using a mild and weak detergent but under no circumstances use fuel or paraffin.

The method of adjusting the belt tension is shown in **FIG 4:4**. Slacken the attachments arrowed and push the generator until the belt tension is correct before tightening the attachments.

4:5 Thermostatic control

Free the retaining spring, arrowed in **FIG 4:5**, so that the righthand flap and shaft can be removed. Unhook the lefthand side flap and free the control cable.

The thermostat itself can be removed after freeing its attachments to its bracket.

Suspend the thermostat in a container of water, so that it does not contact the sides or bottom, and gradually heat the water while stirring with a thermometer. Check that air bubbles do not leak out of the unit and check that it expands as it heats. At a temperature of 60 to 70°C the minimum length of the thermostat, 'a' in **FIG 4:6**, should be 1.8 inch (46 mm). Renew the thermostat if it is defective.

Lubricate all pivot points with molybdenum disulphide paste and install the parts in the reverse order of removal. Make sure that the return spring is correctly fitted as shown in **FIG 4:5**. Clamp the cable so that the valves are shut when the thermostat is cold.

4:6 Fault diagnosis

(a) Engine runs cool, warms up slowly

1 Cooling thermostat defective
2 Linkage sticking or flaps jammed in open position

(b) Engine overheats

1 Air leakage past dipstick or sparking plug seals
2 Air leakage past defective joints
3 Excessive dirt or oil on cooling fins
4 Low engine oil level
5 Mixture too weak
6 Retarded ignition
7 Choked exhaust
8 Binding brakes
9 Slipping clutch
10 Tight engine

(c) Heater ineffective

Determine which portion of the heating system is not operating. If the fuel-fired heater is not operating, take the car to a VW agent.

1 Check (a)
2 Control cables incorrectly set or broken
3 Ducts and pipes disconnected or leaking

NOTES