CHAPTER SEVEN

FUEL INJECTION

The electronic fuel injection system was designed and built by Bosch and has been used successfully on several VW models and other cars.

Complete service information for the fuel injected engine is beyond the scope of this manual. Because of special knowledge and electronic test fixtures required, some services cannot be performed by the home mechanic. The procedures in this chapter permit you to isolate and repair a majority of mechanical troubles, but some mechanical and all electrical unit procedures should be performed by the dealer.

BASIC PRINCIPLES

The heart of the fuel injection system is the control unit, a small electronic "computer." Various sensors transmit information to the control unit concerning air temperature, engine temperature, engine speed, and engine load. The control unit uses this information to determine the exact amount of fuel to be distributed to the cylinders. **Figure 1** is a simplified diagram of the entire fuel injection system; refer to it for the following descriptions. **Figures 2 and** 3 are electrical diagrams which may be helpful when troubleshooting.

Air System

Components of the air system are shown in **Figure 4.** Clean air from the oil bath air cleaner

enters the intake air distributor past a throttle valve to the combustion chambers. The throttle valve controls the flow of air.

During idle, the throttle valve is completely closed. A bypass around the throttle valve permits a small amount of air, controlled by the idle speed screw, to pass. When the engine is cold (below 122•F), the auxiliary air regulator bypasses a larger amount of air around the throttle valve. This extra air mixes with extra fuel injected for cold starts. As the engine warms up, the air regulator gradually closes; when the engine is fully warmed up (above 122 •F), the regulator closes completely.

A pressure switch (1968 & 1969 only) and pressure sensor connect to the intake air distributor to sample manifold pressure and determine engine load.

Fuel System

Figure 5 is a simplified drawing of the fuel system. The fuel pump draws fuel from the front-mounted fuel tank through a filter and delivers it to 4 injectors. A pressure regulator on the return line maintains fuel pressure at 28 psi. Excess fuel from the regulator returns to the fuel tank.

The control unit controls the fuel pump through a relay, not shown in Figure 1 or Figure 4. When the ignition switch is turned on, the



- 1. Fuel tank
- 2. Electric fuel pump
- 3. Fuel filter
- 4. Fuel pressure regulator
- 5. Pressure sensor
- Air intake distributor
 Cylinder head
- 8. Fuel injectors
- 9. Fuel loop line
- 10. Connection for fuel line (cold starting)
- 11.Ignition distributor with trigger
- contacts 12. Electronic control unit
- 13. Throttle valve switch with

- power mixture enrichment 15. Cold starting jet 16. Electro-magnetic valve (cold starting)
- 17. Temperature switch
- (cold starting)
- 18. Auxiliary air regulator

A and B. Signals from pressure sensor C and D. Signals from trigger contacts E and F. Signals from temperature sensors

- (warming up phase) G. Signal from throttle valve switch (fuel shut off on overrun)
- G1. Power mixture enrichment
- 1. Signal from starter (term 50) J. Signal to injectors 1 and 4
- K. Signal to injectors 2 and 3

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- 1. Electric fuelpump
- 8. Injector
- 12.Pressure sensor
- 19. Throttle valve switch with mixture enrichment
- 20.Ignition distributor with trigger contacts
- 21. Thermo (temperature) switch
- 22. Control unit
- 23. Temperature sensor in air intake distributor
- 24. Temperature sensor in
- cylinder head 25. Coldstart valve

- 27. From starter terminal 50
- Pump relay
 Main relay
 To ignition terminal 15 (fuse box)
- 31. To terminal 30 (fuse box)
- 32. To battery + terminal T1, T2, and T3: Wire connectors

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control unit turns the fuel pump on for 1-2 seconds; this prevents flooding the engine if an injector or the cold start valve is defective. The control unit turns the fuel pump back on when the starter is on or the engine is running.

The control unit also controls the electromagnetic fuel injectors. The injectors are turned on in pairs. The control unit sends an electrical pulse to Injectors 1 and 4 simultaneously, and then another pulse to Injectors 2 and 3 simultaneously. On 1968-1971 models, Injectors 1 and 3 inject when the respective intake valve is open, while Injectors 2 and 4 inject when the respective intake valve is closed. On 1972 models, all injection takes place behind closed intake valves. Fuel is effectively stored in the intake ports of cylinders until the intake valve opens.

Figure 6 shows a cutaway of an injector. The control unit sends an electrical pulse to the magnetic winding in the injector. The pulse causes the needle to move off its seat and inject fuel. Then the return spring reseats the needle at the end of the pulse. The time the injector is open varies from about 2-10 milliseconds (0.0020.010 seconds).

The duration of the electrical pulses to the injectors depends mainly on engine speed and engine load. Special contacts in the ignition distributor provide electrical signals to the control unit indicating the engine speed. The pressure sensor generates electrical signals which indicate pressure (vacuum) in the intake air distributor and therefore the engine load. The control unit processes the two electrical signals and determines the duration of electrical pulses to the injectors.

The rate of acceleration and deceleration have an effect on 1970-1972 models. When the driver depresses the accelerator, the throttle valve switch transmits an electrical signal to the control unit indicating how fast the pedal is being depressed. The control unit uses this information to compute how many extra injections are needed and how long injection duration should be. When the driver eases up on the accelerator pedal, the throttle valve switch transmits another signal to the control unit. On 1970 and 1971 models, if engine speed is above 1,800 rpm, the control unit actually shuts off all injec-



1. Filter
 2. Magnetic winding
 3. Return spring
 4. Magnetic armature
 5. Sealing needle

tion until the speed drops to about 1,250 rpm. At this point, injection begins again, permitting a smooth transition to idle speed if the car continues to decelerate. Naturally, if the driver depresses the accelerator below 1,800 rpm and before reaching 1,250 rpm, the control unit resumes injection immediately. This method of leaning mixtures has been discontinued in favor of an air injection system on 1972 models. Air injection is described in a later section in this chapter.

Different means are used to signal enrichment for full throttle acceleration. On 1968 and 1969 models, a pressure switch connected to the intake air distributor signals when pressure approaches atmospheric pressure (wide-open throttle valve). On 1970 and 1971 models, the pressure switch is included in the pressure sensor. In 1972, VW installed a new throttle valve switch with extra contacts to signal full throttle.

In addition to engine speed and engine load signals, the control unit receives signals from temperature sensors. On 1968 and 1969 models, one sensor monitors crankcase temperature, while another monitors cylinder head temperature. On 1970-1972 models, one sensor monitors temperature of incoming air while another monitors cylinder head temperature as in previous years. The control unit "computes" the effect these sensors should have on the injectors. When the sensors detect cold temperatures, the control unit increases injection duration.

Cold Start System

When the engine is cold, but above 5 \bullet F (-15•C) on 1968 and 1969 models, or 50•F (10•C) on 1970-1972 models, the control unit orders additional fuel injected during starting. The temperature sensors described earlier provide the temperature information.

When the temperature is below 5•F (1968 and 1969) or 50•F (1970-1972), even more fuel must be injected. A special cold start system provides this additional fuel. See Figure 1. The cold start thermostat operates the cold start valve through a relay. The cold start valve injects

extra fuel through a jet fitted in the intake air distributor.

SERVICE PRECAUTIONS

The same precautions which apply to carburetor fuel systems apply to fuel injected systems, only more so. Before suspecting any trouble in the fuel system, thoroughly check out the ignition system, including spark plugs. Whenever disconnecting any fuel lines, clean away all traces of dirt from the end of the line before disconnecting it. When the line is reconnected, examine the line for dirt. Even very small dust particles can jam the injectors.

There are a few more precautions which should be observed when working on the fuel injected engine. Never run the engine with the battery disconnected. And do not use a battery charger to start the car when the battery is dead. Furthermore, if you want to charge the dead battery, disconnect it first. If these precautions are ignored, the voltage to the control unit can rise high enough to cause expensive damage.

AIR CLEANER

Removal/Installation

Refer to **Figure 7** for the following procedure. 1. Disconnect all small hoses (B) from air cleaner. The number of hoses varies with year.



Mark them permanently so they may be removed and reconnected easily.

2. Open clamp (A) securing intake boot to air cleaner. Pull boot off air cleaner.

3. Loosen clamp (D) securing rubber boot to intake air distributor. Pull boot off air distributor.4. Unscrew wind nut (E) on top of air cleaner. 5. Lift air cleaner off.

NOTE: Air cleaner contains oil. Do not tip or oil will spill.

6. Clean air cleaner if necessary. See Chapter Two.7. Installation is the reverse of these steps. Be sure that the red arrows (G) are aligned.

ACCELERATOR CABLE REPLACEMENT

The accelerator cable connects the accelerator, through the frame tunnel and front engine cover plate, to the throttle valve in the intake air distributor.

1. Loosen clamp bolt on throttle lever and disconnect cable.

2. Fold accelerator cable forward. Unhook cable from lever and pull cable out through the front.

3. Ensure that the plastic tubing and rubber boot are securely in place and that the tubing is routed alongside the transaxle.

4. Grease the cable with universal grease and install it through guide tube in frame tunnel. The cable must lay straight with no kinks.

5. Insert cable end into throttle link.

6. Have an assistant fully depress the accelerator pedal. Open the throttle valve until there is about 0.04" (1mm) clearance between the throttle lever and stop. Tighten cable clamp screw.

CONTROL UNIT

The control unit is a complex electronic device requiring very specialized knowledge and equipment to check and repair. At the present time no U.S. dealers are equipped to service these units. Instead, an exchange is made and the defective unit returned to Germany.

Removal/Installation

1 a. On Fastback Sedans, lift flap on left side of rear luggage area.

1 b. On Squareback Sedans, remove luggage compartment lining.

2. Remove 2 Phillips screws on cover plate. See

Figure 8.



3. Tilt control unit forward and lift upward to remove. 4. Open cable clamp and remove end cover. See **Figure** 9.



5. Disconnect multiple plug from control unit. 6. Installation is the reverse of these steps. Always clean contacts of multiple plug and socket with television tuner contact cleaner before reconnecting.

RELAYS

There are 2 relays important to the fuel injection system. The main power relay supplies power to the control unit and the fuel pump relay. Both relays are located on the left side of the engine compartment.

Testin

Failure of either relay will prevent starting the engine. When relays are suspected, always check the main power relay first. To do this:

1. Turn ignition switch on.

2. Measure voltage at pin 87. The voltage should be 12 volts.

3. If pin 87 measures 12 volts, the main power relay is good, but the fuel pump relay may be at fault.

4. If pin 87 does not measure 12 volts, check pin 86. If 12 volts is present at pin 86, the relay is defective; replace it. If 12 volts is not present at pin 86, check wiring back to ignition switch. See Chapter Eight for wiring diagrams.

If the main power relay is good, check the fuel pump relay. To do this:

1. Turn ignition switch on to operate main power relay.

2. Measure pin 87 on fuel pump relay. If it measures 12 volts, the relay is good; the fuel pump may be defective.

3. If pin 87 measures 0 volts, check pins 86 and 30/51. Both should be 12 volts. If they are, replace the relay. If either pin is O volts, check wiring to that pin. See Chapter Eight for wiring diagrams.

Relay Replacement

1. Disconnect battery ground cable.

2. Remove screw securing relay to engine compartment. Pull relay out so that wires are visible. 3. Remove wires from relay one at a time and mark them.

4. Install wires on new relay. Connect wires carefully so they are not interchanged.

5. Secure relay to engine compartment with screw.

FUEL PUMP

The fuel pump is located at the rear of the fuel tank near the steering gear.

Testing

The fuel pump only operates for about $1 \frac{1}{2}$ seconds when the ignition switch is turned on.

To operate the fuel pump longer to test operation, disconnect T1/19 in the wire to pin 85 of the fuel pump relay. See Figure 2 or 3. Ground the wire to pin 85. The pump should run as long as the wire is grounded.

If the pump doesn't run at all, check electrical connectors to pump. Check voltage on pin 87 when 85 is grounded. If it measures 12 volts, the pump is bad; if it measures 0 volts, the pump relay is bad. If fuel pump runs, check its delivery capacity. To do this:

1. Disconnect fuel line between right fuel distributor pipe and fuel pressure regulator at the distributor pipe.

2. Connect a long hose to the right fuel distributor pipe. Put the other end in a gallon container.

3. Disconnect and ground T1/19 as described above to run the pump.

4. Let the pump run for exactly 30 seconds. The container should contain 1 1/2 quarts or more of fuel.

5. If the pump delivers less than specified, the trouble could be a restricted tank vent, restricted fuel filter or line, or a defective fuel pump.

Removal/Installation

1. Clamp all fuel lines on the pump.

2. Disconnect electrical wires to pump.

3. Cut off crimped hose clamp(s) on fuel lines.

Some models have just 1, others have 3.

4. Remove nuts securing pump to frame and remove pump.

5. Installation is the reverse of these steps. Use new hose clamps at fuel pump.

FUEL PRESSURE REGULATOR

Testing and Adjustment

This is not a routine maintenance procedure. Do not adjust unless trouble is suspected or a new regulator has been installed. 1. Remove air cleaner. 2. Remove screw plug in right fuel distribution pipe. Connect fuel pressure gauge capable of measuring about 40 psi. See **Figure 10**.



3. Start engine. Check for leaks around pressure gauge connection. 4. Fuel pressure should be 28 psi (2.0 kg/cm'). If the pressure is not correct, loosen the lock nut on the regulator (see **Figure 11**) and adjust pressure. Retighten the lock nut.

NOTE: In hot climates, it is permissible to increase fuel pressure to 31 psi. This helps prevent vapor lock. Consult your dealer before doing this, however; there may be other troubles that should be repaired.



A - Locknut B - Adjusting

5. If fuel pressure cannot be adjusted to 28 psi, replace pressure regulator as described below.

Removal/Installation

1. Raise rear of vehicle on jackstands.

2. Clamp fuel line on front of the pressure regulator.

3. Lower vehicle.

- 4. Remove air cleaner as described previously.
- 5. Unscrew right side of front engine cover
- plate on which regulator is mounted.
- 6. Bend cover plate back gently to gain access to front end of regulator.
- 7. Disconnect fuel line from regulator.

8. Remove bolt securing regulator to cover plate.

9. Remove regulator and disconnect other fuel line from it.

10. Installation is the reverse of these steps. Install a new rubber seal between regulator and engine cover plate.

NOTE: 1972 vehicles destined for California have a special fuel regulator. This unit must not be interchanged with older regulators.

INJECTORS

Testing

This test assumes that the engine misfires or runs erratically and the ignition system has been checked out.

1. Disconnect one spark plug wire at a time while the engine is running. When the spark plug wire of a faulty cylinder is removed, the engine misfiring will not increase. Removing the plug wire from a good cylinder will increase roughness and misfiring.

2. To determine if the injector or the control unit is at fault, remove the suspected injector and interchange it with the adjacent injector. Be extremely careful not to get any dirt in the system.

3. Test the two injectors as in step 1. If the trouble has moved to the adjacent cylinder, the suspected injector is at fault. If the trouble is in the same cylinder, the control unit is at fault.

Sometimes a mixture trouble is indicated in a single cylinder by the spark plug appearance. The following procedure provides a quick check of injector performance.

1. Disconnect the high voltage output of the ignition coil so the engine will not start when the key is engaged.

2. Remove suspected injector pair, following steps 1-3 of removal procedure below.

3. Reconnect electrical cables to injectors.

4. Hold a small container under injectors to collect fuel.

5. Turn the ignition switch on, but do not crank the engine.

6. When fuel pressure builds up, the end of the injector may be wet with fuel but should not leak more than 2 drops per minute. A larger leak may cause an overly rich mixture to one cylinder.

7. Crank the engine and note if the injector squirts fuel. If it works at all, it is probably good. To be certain, reinstall it in a different cylinder and examine the plugs again after driving several miles.

Removal/Installation

Refer to **Figure 12** for the following procedure.

1. Disconnect electrical cable from injector. 2. Remove 2 nuts securing injector retainer. 3. Carefully lift out both injectors together with all mounting hardware. Ensure that seals are on ends of injectors. See **Figure 13.** If not, carefully pry seals out of intake manifold seats.

CAUTION Keep the ends of the injectors clean. Even very small dust particles can jam injectors.



4. Pull injector plate and rubber bushings off injectors.

5. Loosen hose clamp on injector to be removed and pull injector off.

6. Installation is the reverse of these steps. Use new seals, and torque nuts to 4.3 foot-pounds (0.6 mkg).

7. Start engine, check for leaks, and check engine performance.

THROTTLE VALVE SWITCH

The throttle valve is located on the right front side of the intake air distributor. See **Figure 14**.





Testing

Because of the complex interaction among components in the fuel injection system, it is difficult to trace a throttle valve switch malfunction with a single test. If the following test is performed satisfactorily, the throttle valve must be working; however, if the test fails, there are many other potential causes outside of a defective throttle valve switch.

1. Switch on the ignition switch but do not start the engine.

2. Open and close the throttle valve slowly. Listen for small clicks from the injectors indicating extra fuel for acceleration being supplied. 3. Start the engine and let it warm up.

4. Temporarily disconnect the hose between the intake duct and the side of the air regulator. There are two hoses here; one comes out the top of the regulator and one comes out the side. Be sure to get the right one.

5. The engine speed should slowly fluctuate between approximately 900 rpm and 1,700 rpm. This indicates the throttle valve contacts and that portion of the control unit which meters fuel during deceleration are working properly.

Removal/Installatio

1. Remove air cleaner as described earlier. 2. Disconnect electrical cable to switch.

3. Remove 2 screws securing switch to intake air distributor and remove switch. See **Figure 15.** 4. Installation is the reverse of this procedure.



Cable plug must be on top when switch is installed.

5. Adjust switch position.

NOTE: A different throttle valve is used for each year. They are NOT interchangeable.

Adjustment

1. Loosen mounting screws on throttle valve switch.

2. Look inside intake air distributor and ensure that the throttle valve is completely closed.

3. Disconnect electrical cable to switch.

4. Connect an ohmmeter (set to R x 10) across contacts on switch plug.

5. Rotate the switch slowly in the slotted mount ing holes until the switch just closes, i.e., the ohmmeter reads 0.

6. Turn the switch counterclockwise 1 major graduation (2•). See **Figure 16.** Tighten mount ing screws.



PRESSURE SWITCH

The pressure switch is located under the right intake manifold on 1968 and 1969 models only. See **Figure 17**.



Testing

1. Disconnect electrical cable to pressure switch.

2. Connect ohmmeter (set to R x 10) across switch terminals.

3. Start engine.

4. Resistance should be infinity.

5. Open the throttle rapidly, then release it. Manifold pressure should drop to 0-1". Watch the ohmmeter; it should go to 0 ohms, indicating the switch is closing properly.

Removal/Installatio

1. Remove air cleaner.

2. Remove mounting bolt between right manifolds. See **Figure 18**.



3. Disconnect vacuum line and electrical cable. 4. Remove switch. 5. Installation is the reverse of these steps.

AUXILIARY AIR REGULATOR

The auxiliary air regulator is located on the crankcase near the base of the distributor. See **Figure 19.**



Testing

1. Start engine; warm up thoroughly so that regulator closes completely.

2. Note engine idle speed, then disconnect the air hose to the air regulator at the air cleaner.

3. Cover the end of hose with your hand. If engine speed drops noticeably, the air regulator leaks and must be replaced.

Removal/ Installation

1. Disconnect air hoses and electrical cable from air regulator.

2a. On 1968-1969 models, remove crankcase temperature sensor which is mounted in the base of the air regulator. Remove air regulator mounting bolt.

2b. On 1970-1972 models, remove 2 mounting bolts.

3. Lift regulator out.

4. Cover hole in crankcase to prevent entry of dirt.

5. Installation is the reverse of these steps. Use a new gasket under the air regulator.

PRESSURE SENSOR

The pressure sensor is located on the left side of the engine compartment. See **Figure 20**.



Removal/Installation

1. Disconnect electrical cable from sensor. Dis connect ground wire on 1972 sensors.

2. Loosen front mounting screw. Remove rear mounting screws.

3. Slide sensor toward the rear and remove it.

4. Disconnect vacuum hose.

5. Installation is the reverse of these steps.

NOTE: A different sensor is used for each year. They are NOT interchangeable.

HEAD TEMPERATURE SENSOR

The head temperature sensor is located on the bottom side of the left cylinder head on 1968-1969 models. See **Figure 21.** On 1970



1972 models, it is located on top and is accessible from the engine compartment through an access hole. See **Figure 22**.



Testing

With engine idling and warmed up, connect voltmeter across sensor. The voltage drop should be 0.2-0.4 volts. A 12 volt reading indicates an open sensor which must be replaced; an open sensor prevents the engine from running.

The sensor may also be tested with an ohmmeter. It should measure 2,500 ohms when cold and 60 ohms when hot; disconnect wire to measure.

Removal/Installation

1. Disconnect cable connector on temperature sensor cable. See Figure 21 or Figure 22.

2. Raise rear of 1968 or 1969 vehicle on jackstands.

3. Unscrew temperature sensor.

4. Installation is the reverse of these steps. Do not overtighten sensor.

NOTE: 1968-1972 sensors are the same.

CRANKCASE TEMPERATURE SENSOR (1968 & 1969)

The crankcase temperature sensor is used as a mounting bolt for the auxiliary air regulator. See **Figure 23**.



Testing

Disconnect the electrical cable to the sensor. Measure across terminals with an ohmmeter. Resistance when cold should be 500 ohms; resistance when hot should be 100 ohms.

Removal/Installatio

1. Disconnect electrical cable on sensor.

2. Unscrew sensor from auxiliary air regulator. 3. Installation is the reverse of these steps.

NOTE: 1968 and 1969 sensors are the same.

INTAKE AIR TEMPERATURE SENSOR (1970-1972)

The intake air temperature sensor is mounted on the left side of the intake air distributor. See **Figure 24**.

Removal/Installatio

1. Disconnect electrical cable on sensor.

2. Unscrew sensor from auxiliary air regulator. 3. Installation is the reverse of these steps.

NOTE: 1970-1972 sensors are the same.

DISTRIBUTOR TRIGGER CONTACTS

Testing

Faulty triggering contacts can cause misfiring or complete failure to start. This procedure will verify that the contacts work.



1. Disconnect the high voltage output of the ignition coil so the engine won't start when cranked.

2. Disconnect the electrical plug to the distributor triggering contacts.

3. Connect an ohmmeter between the center terminal on the distributor contact plug and one of the other terminals.

4. Crank the engine over. The ohmmeter will fluctuate between 0 and infinity, indicating the contact is open and closing properly.

5. Connect the ohmmeter between the center terminal and the other end terminal.

6. Crank the engine and look for the same indications as in step 4.

7. If either contact fails, replace the contacts. The procedure for changing the contacts is included in the Electrical System chapter.

INTAKE MANIFOLDS

Removal

1. Remove air cleaner. 2. Remove pressure switch. 3. Remove injectors but leave them on their mounting plates. 4. Remove 4 screws securing inner and outer cover plates and remove cover plates. See **Figure 25**.



5. Remove 2 nuts and washers securing manifold and remove it from hoses. See **Figure 26**.



Installation

1. Install inner cover plate, but do not tighten screws. Install injector ground connections under screws. 2. Install manifold with new gasket. 3. Install outer cover plate. 4. Install injectors. 5. Install pressure switch. 6. Install air cleaner.

INTAKE AIR DISTRIBUTOR

Removal/Installation

1. Remove air cleaner and pressure switch. 2. Make a special tool with dimensions shown in **Figure 27.**



| u. 1.77 m. (45mm) | 1. 7.40 III. (17011 |
|---------------------|---------------------|
| b69 in. (17.5mm) | g. 7.87 in. (200m |
| c. 1.77 in. (45mm) | h08 in. (2mm) |
| d. 3.94 in. (IOOmm) | i12 in. (3mm) |
| e. 3.66 in. (93mm) | |
| | |

3. Use special tool to slide 4 hoses off intake air distributor and onto intake manifold. See **Figure 28**.



4. Remove throttle valve switch. 5. Disconnect accelerator cable. 6. Disconnect vacuum hose between intake air distributor and ignition distributor.

7. Disconnect air hose to auxiliary air regulator.
8. Loosen bolts shown in Figure 29 and remove air distributor.
9. Installation is the reverse of these steps.



COLD START SYSTEM

The cold start system consists of a cold start valve (1), thermostat (2), relay (3), and fuel line (4) from the right-hand fuel distributor. See **Figure 30.**



Cold Start Valve Removal/Installation

- 1. Disconnect fuel lines from valve.
- 2. Disconnect 2 electrical wires from valve.
- 3. Remove screws attaching bracket for valve
- and thermostat to intake air distributor.
- 4. Remove 2 screws securing valve to bracket.
- 5. Installation is the reverse of these steps.

Thermostat Removal/Installation

1. Disconnect wire from thermostat.

2. Unscrew from bracket. 3. Installation is the reverse of these steps.

Relay

1. Remove protective cap over relay.

2. Disconnect wires and mark with terminal numbers.

3. Remove screw securing relay to engine compartment.

4. Installation is the reverse of these steps. Make certain the wires are connected properly.

Adding Cold Start System

If your early 1968 vehicle does not have a cold start system, you can add one easily enough. Purchase a kit of parts from your VW dealer. It should contain:

- a. bracket
- b. relay
- c. cold start valve
- d. thermostat
- e. wiring harness
- f. end cover plate with jet
- g. length of hose

Proceed as follows:

- 1. Remove intake air distributor as described later.
- 2. Remove end plate from air distributor and install new end plate with jet. See **Figure 31**.

3. Mount thermostat and cold start valve to bracket as shown in Figure 31.

4. Install intake air distributor and bracket, but leave air cleaner off.

5. Connect a length of fuel line between end plate and cold start valve. Secure both ends with hose clamps.

6. Remove screw from pressure gauge connection on right fuel distributor. See Figure 10.

7. Connect a length of fuel line between pressure gauge connection and cold start valve. See Figure 31. Secure with hose clamps.

8. Drill 6mm hole on right side of engine compartment to mount relay (see 3, Figure 30).

9. Connect wiring harness in kit to relay according to **Figure 32.** Install relay in hole drilled previously.



10. Disconnect plug from pressure switch. Cut cable as near to the base of the plug as possible. 11. Strip insulation off end of wire 9 (number is printed on insulation) which was cut above. Connect with blue wire in cold start wiring harness with connector. Wire 14, which was also cut, is left in cable tubing; it is not used.

12. Install flat connector on starter terminal 50. Feed wire 3 of harness through front engine cover plate and connect to flat terminal.

13. Locate ground 1 1 near throttle valve switch (see Figure 3). Add a second flat connector and connect the brown ground wire from the harness.14. Connect wires to thermostat and cold start valve. Install harness plug on pressure switch.15. Install air cleaner.

EXHAUST EMISSION CONTROL

Crankcase Ventilation

Two different ventilation systems are used. On 1968-1971 models, crankcase vapors enter the oil breather through an integral valve and are routed through a hose to the air cleaner.

Ventilation on 1972 models is more sophisticated and thorough. See **Figure 33.** Fresh air from the air cleaner passes through hoses to the valve covers. This air circulates through the crankcase and is drawn out through the oil breather and introduced into the intake air distributor.

Fuel Cutoff (1968-1971)

In order to lean out the air/fuel mixture dur-



ing coasting and reduce emissions, 1968-1971 models shut off the fuel supply. Special contacts in the throttle valve switch signal when the throttle valve is closed.

Air Injection (1972)

On 1972 models, additional air is injected to lean the mixture during coasting rather than cutting off the fuel supply. **Figure** 34 shows the system used on models equipped with a manual transaxle. When coasting, the throttle valve closes and a high depression (vacuum) exists in the intake air distributor. This vacuum operates a valve (1) which opens and admits air from the air cleaner around the throttle valve to lean the mixture.



A slightly different valve is used on models with automatics. An oil pressure switch on the automatic transmission generates an electrical signal to open the air valve. Otherwise, operation and function of the valve is identical to that on manuals.

CO Adjustments (1972)

A different control unit (Part No. 311 906 021E) is used in 1972 models. This unit has an adjustable potentiometer to adjust carbon monoxide levels to 0.7% or less. See Chapter Two for adjustment procedure. No adjustment is possible on earlier models.

FUEL EVAPORATIVE CONTROL SYSTEM

All 1970-1972 VW's sold in California are equipped with a fuel evaporative control system

which prevents release of fuel vapor into the atmosphere.

Refer to **Figure** 35. Fuel vapor from the fuel tank passes through the expansion tank to the activated charcoal filter. When the engine runs, cool air from the fan housing forces the fuel vapor into the air cleaner. Instead of being released into the atmosphere, the fuel vapor takes part in the normal combustion process.

There is no preventive maintenance other than checking the tightness and condition of the lines connecting parts of the system. The expansion tank is located in the left front wheel well. See **Figure 36.** The activated charcoal filter is located on the left side of the engine compartment. See **Figure 37.**



