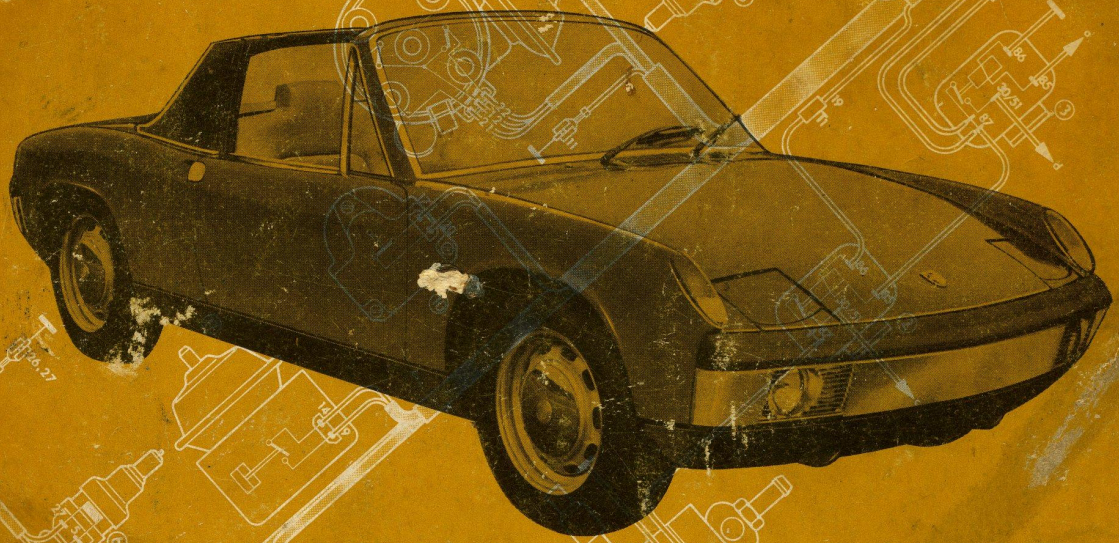
VOLKSWAGEN
FUEL INJECTION
TECHNICAL MANUAL

HENRY ELFRINK



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FUEL INJECTION
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FOURTH ENLARGED EDITION

HENRY ELFRINK AUTOMOTIVE
P.O. BOX 20367
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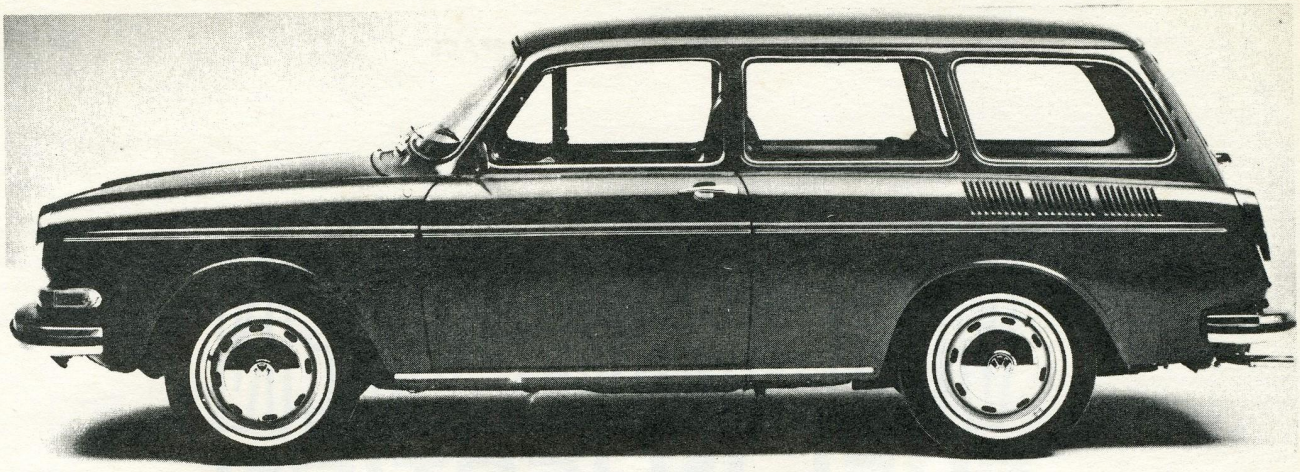
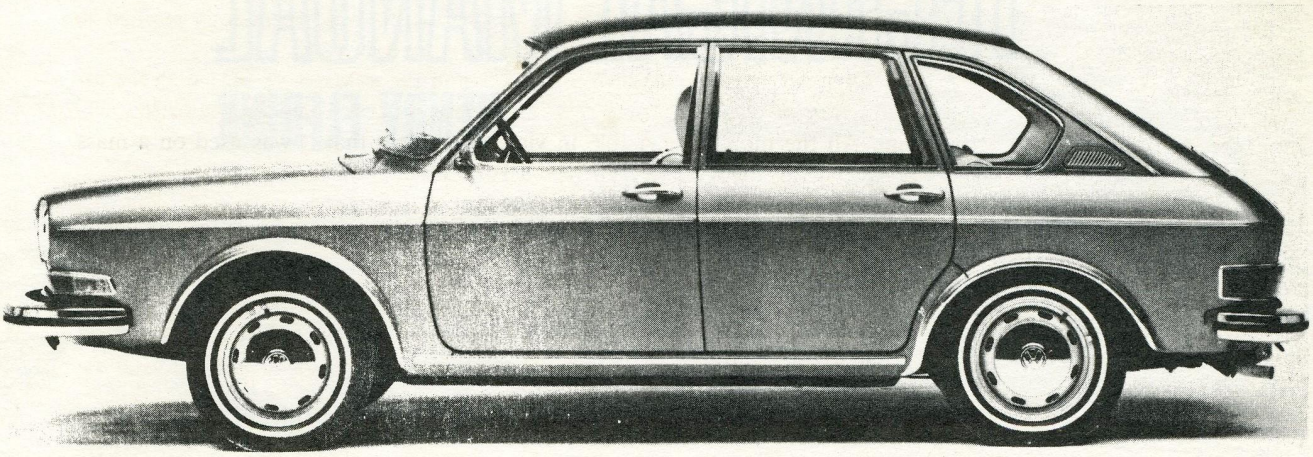
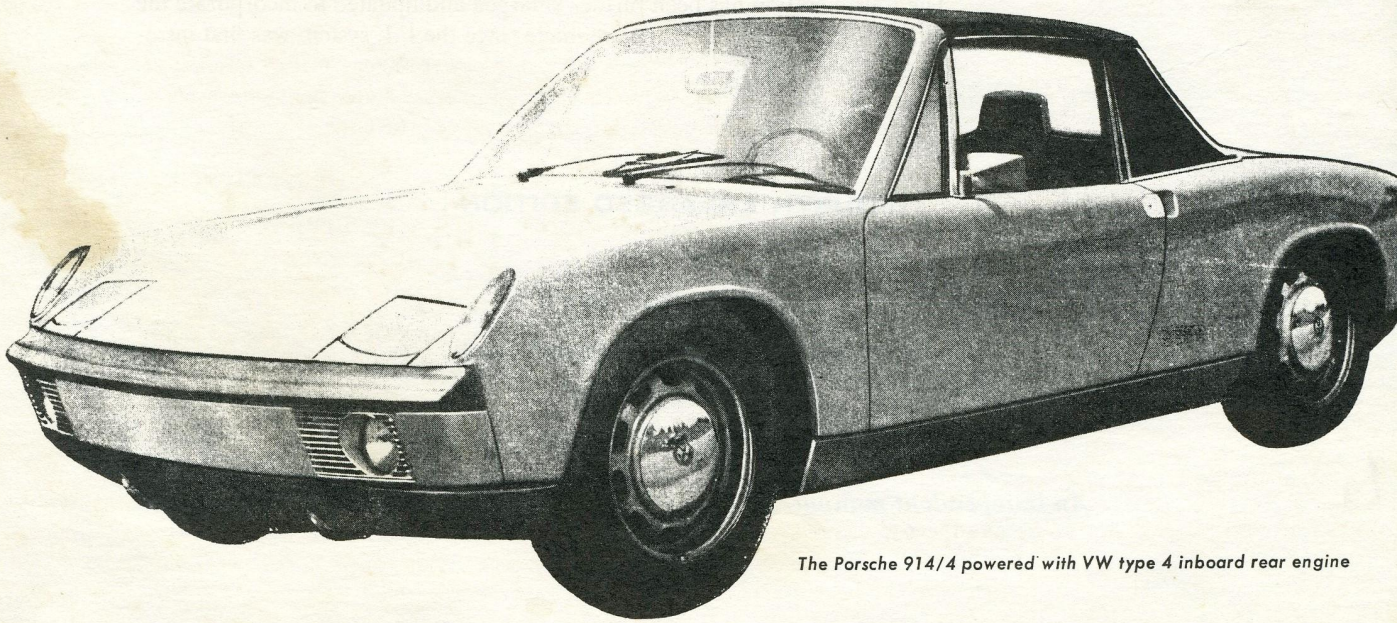


Type 3 Variant wagon (1971 model)



The type 411 4 door sedan (1971 model)



The Porsche 914/4 powered with VW type 4 inboard rear engine

PREFACE

In this completely new technical manual, the first privately published on the revolutionary Volkswagen-Bosch electronic fuel injection system, we are offering material which should enable the mechanic, engineer as well as the layman to easily understand the fundamentals of this new principle in the automotive field.

Inasmuch as electronic fuel injection is a new automotive application, we have decided to devote a separate book to it. This manual is complementary to our regular VW 1600 technical manual.

The Robert Bosch company is a pioneer in the field of fuel injection. They took the first tentative steps with a mechanical injection system in 1912, but the still primitive automotive industry was not yet ready for this application.

In the thirties Bosch experimented with fuel injection on aircraft engines and in 1937 a Bosch mechanical fuel injection system was used on the famous DB 1200 aircraft engines. In 1944 all German combat aircraft were powered with Bosch fuel injected engines.

In the fifties the mechanical injection principle was successfully applied to German racing cars and later on expensive passenger cars.

The year 1967 established a milestone in the automotive field with the introduction of the completely new electronically controlled fuel injection system. All the more remarkable in view of the fact that it was used on a mass produced car, the Volkswagen type 3 1600 model.

Since its introduction in 1967, the F.I. system has gone through a continuous process of development, and there have been many detail modifications. However, the basic principles have not changed.

Inasmuch as many cars using the earlier systems are still on the road, a description of the older versions will be given first. Subsequent modifications are covered later in the book. A table showing the various units used through the years also is included.

The writer feels that he is well qualified to have written this book; he has participated in a thorough service course on this fuel injection system at the Volkswagen factory in Wolfsburg and has since then checked out many fuel injection systems in the shop with the special testing instruments especially acquired for this purpose.

The fourth edition has been further enlarged and updated to incorporate the many detail modifications that were made since the F.I. system was first introduced on VW cars in 1967. The latest systems offer better starting, quicker response to changing traffic conditions and also provide better fuel consumption.

The earlier systems are covered in the first part of the book.

HENRY ELFRINK

January 1972

ACKNOWLEDGMENTS

We gratefully extend our thanks to the following companies for their assistance and cooperation for the information, data and illustrations used throughout this book: Volkswagenwerk AG, Wolfsburg, Germany; Volkswagen of America Inc., Englewood Cliffs, N.J., USA; Robert Bosch GmbH, Stuttgart, Germany; Robert Bosch Corp., San Francisco, USA.

My special thanks to Clarence Kremser who took many of the photos which appear in this manual.

H. E.

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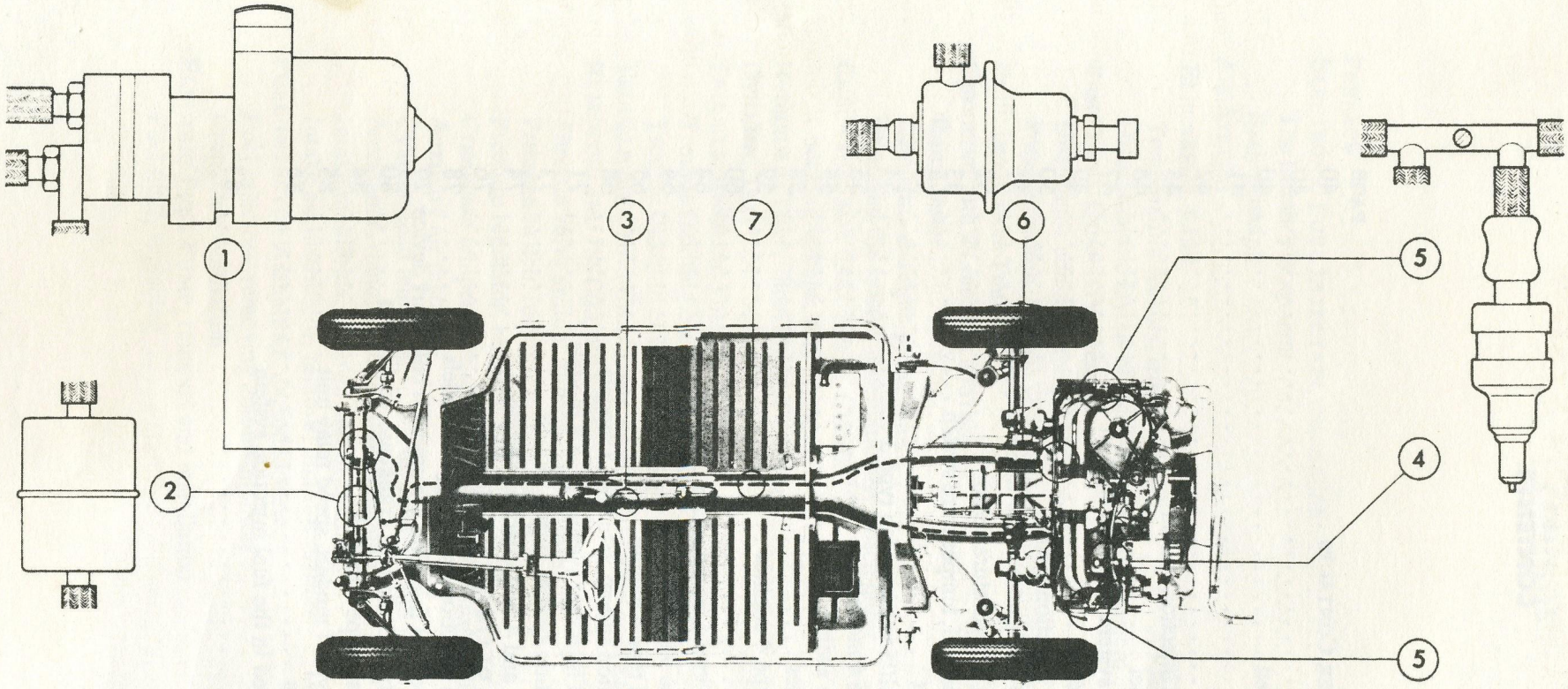


The location of the various components is shown in this illustration. The electric fuel pump 1 draws fuel from the front-mounted tank through filter 2 and forces it through pressure line 3 into the so-called main loop line 4 from where fuel is directed to the four electro-magnetic injectors. Pressure regulator 6 maintains a constant line pressure of 2 atm (29 psi). Surplus fuel flows back to the fuel tank through return line 7 which is not pressurized. The bypass return line from the fuel tank also feeds into this line. A diagrammatic representation of the injection system is shown on page 8

THE ELECTRONIC FUEL INJECTION SYSTEM

FUEL INJECTION (DESCRIPTION)

Fuel injection for internal combustion engines has been used for a number of years on high performance competition cars and some expensive production automobiles. Although fuel injection has many advantages, the very high cost of the equipment has prevented its use for the more popular makes.

There are many different fuel injection systems. The simplest, but also least effective is the constant flow, low pressure system whereby fuel is injected into the intake manifold in a constant stream. Then there is the timed high pressure direct injection system. Here fuel is injected under high pressure directly into the cylinder. This sophisticated system is very efficient but highly complicated and therefore very expensive. In principle it is not unlike the high pressure direct fuel injection in Diesel engines.

The most popular system at this writing is the indirect timed injection system whereby fuel is injected intermittently into the intake manifold close to the intake valves. In the majority of cases the parameters for correct fuel dosage are engine speed (rpm), manifold pressure, throttle position, temperature.

The famous Robert Bosch company has been a pioneer in the development and manufacture of the fuel injection systems. It not only has manufactured injection equipment for the Diesel engines for decades, but also specialized injection equipment for some of the world's most famous racing and competition cars.

Bosch manufactures the fuel injection equipment for some of the most expensive Porsche production models (as well as their racing cars). Porsche uses the Bosch mechanical indirect timed injection system which injects fuel under rather high pressure (about 18 atm-265 psi) into the intake manifold, behind the intake valve.

The Bosch-VW System

For Volkswagen however a completely different system is used, also designed and manufactured by Bosch. The system used is electronically controlled and completely new. It marks the first use of such a system in the automotive field. It was developed by Bosch in close cooperation with VW and was first used in 1967 (for the 1968 fastback and Variant models).

This period can be considered a milestone since it marks the first time that a fuel injection system was used as standard equipment in a mass produced car and the first time ever that an electronic system was employed in this special field.

The electronic control unit (a solid state computer) is situated in the air duct of the left rear quarter panel of the body. This unit determines the amount of fuel needed for efficient combustion according to the variables of the engine speed (rpm), engine load (manifold pressure) and engine temperature.

Although electronically controlled fuel injection breaks completely new ground it has proved to be very reliable and efficient. Apart from the electrically driven fuel pump, the injectors and some sensors, its operation is fully electronic not using any moving mechanical parts.

Advantages

The Bosch electronically controlled fuel injection system has many advantages. Fuel is injected intermittently under low pressure (in this case at around 2 atm-28 psi) by means of electro-magnetic injectors into the intake ports behind the intake valves. This provides good atomization of the mixture and equal distribution to all cylinders.

This makes for a high specific power output, low specific fuel consumption, favorable torque values throughout the rpm range, complete com-

bustion with a very low emission of air contaminants and a fast throttle response.

In addition, since the injectors are completely cut off when the ignition is switched off, running on of a hot engine is prevented. Consequently the special idle cut-off jets fitted to the carbureted VW engines are not needed in the injection engine.

Basic principle

The VW-Bosch electronic injection system can be classified as a low pressure, intermittently operating timed injection system with fuel injection by electro-magnetically actuated injectors. The injectors are of the constant lift type, and since the fuel is injected under constant pressure, the injected quantity is a function of time only.

The required amount of fuel injected is determined according to many parameters (to be discussed later) by the electronic control unit. This unit contains all the electronic circuitry on a printed circuit board in a sheet metal case. It is situated in the left rear quarter body panel. It contains more than 200 transistors, diodes and condensers. Under all conditions of engine operation it squirts exactly the correct amount of fuel into the intake ports according to prevailing rpm, engine load and temperature. Combustion is virtually complete resulting in a very clean exhaust.

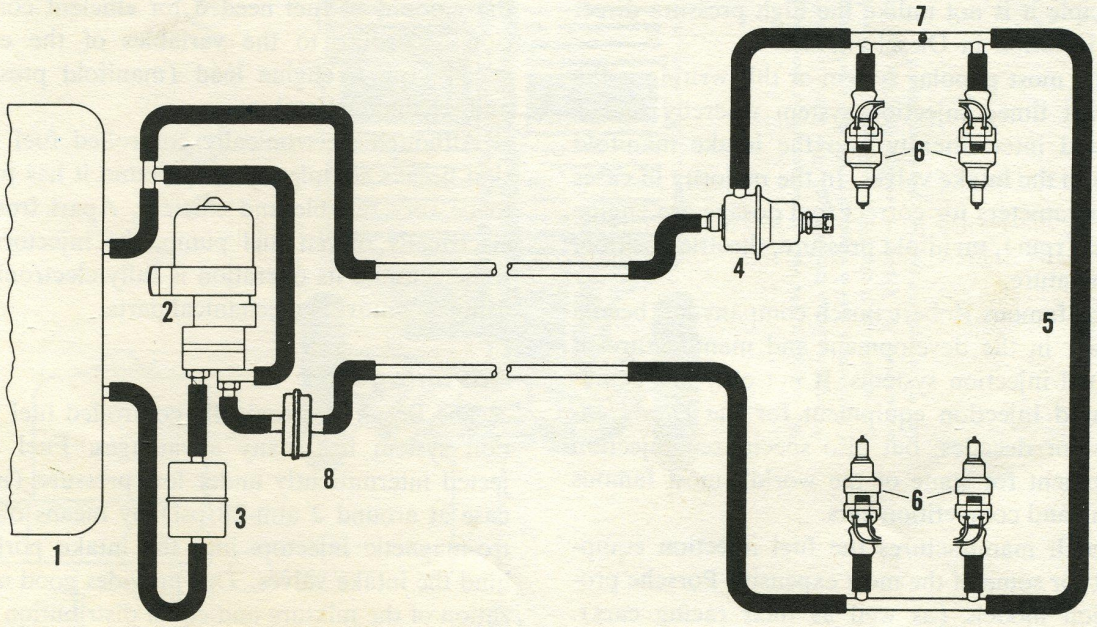
The accompanying illustration shows the layout of the complete system. Fuel from the front-mounted tank goes through a filter 2 into the pressure line 3 to the so-called fuel line loop on top of the engine.

Constant fuel pressure

One of the main characteristics of this fuel injection system is that a constant fuel pressure is rigidly maintained at 2 atm (about 28 psi) by the pressure regulator 6. Surplus fuel flows back to the front tank through return line 7 which is not pressurized. The bypass return line from the electric fuel pump goes into this line.

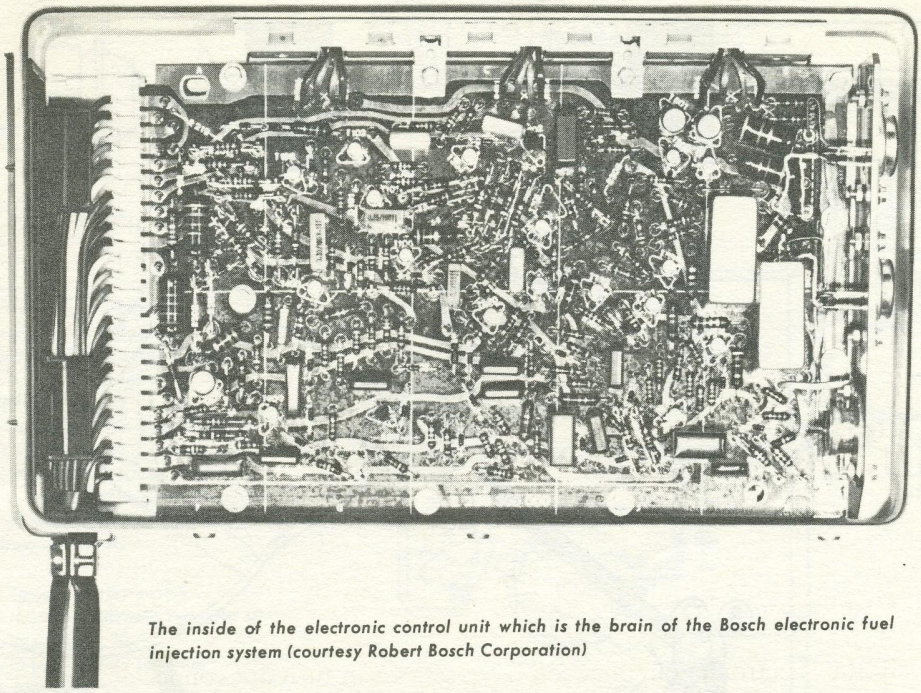
Fuel is injected into the cylinders by four electro-magnetic injectors (one for each cylinder) which in turn are connected to the fuel loop line. The injectors are mounted to the intake manifolds near the cylinderhead and fuel is injected intermittently, just behind the intake valve.

The amount of fuel injected is a direct function of the injection pressure and in this system a care-



Diagrammatic view of fuel injection system. Also see illustration on page 6

1. fuel tank
2. fuel pump
3. filter
4. pressure regulator
5. fuel loop line
6. electro-magnetic injectors
7. screw for pressure gauge connection
8. damper



The inside of the electronic control unit which is the brain of the Bosch electronic fuel injection system (courtesy Robert Bosch Corporation)

fully controlled constant pressure is maintained. Variations in the quantity of the fuel injected are through time differentials rather than pressure variations. In other words, with this system, time is a key parameter for the amount of fuel injected.

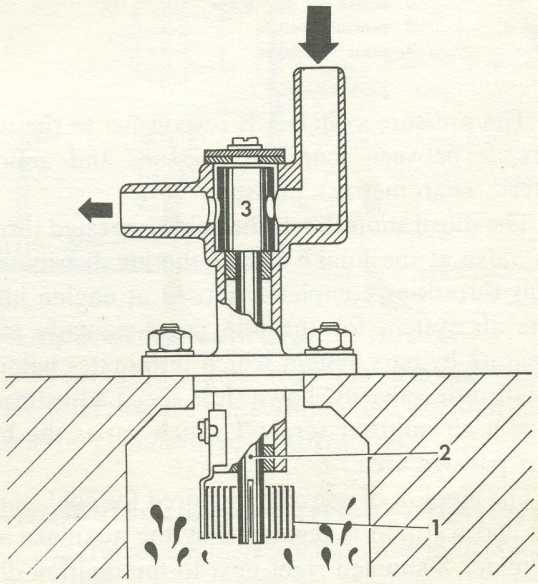
The fuel pump itself is an electrically-driven roller type rotary pump. Situated in the pressure side is a check valve, a breather valve and a pressure relief valve.

AIR SYSTEM

The air necessary to form a combustible mixture with the injected fuel is supplied through the four intake manifolds 1 which connect to the intake air distributor 2. A pressure switch 3 and pressure sensor 4 and the vacuum line connection for the ignition spark advance also connect to the air distributor.

A conventional oil bath aircleaner is hooked up to the air distributor as can be seen in the illustration. The intake manifolds in this system of course only carry pure air and not a combustible air-fuel mixture as is the case with conventional carburetor engines.

The pressure sensor 4 is responsive to the actual (absolute) pressure in the intake manifold. This so-called *manifold pressure* varies with the throttle opening and is a basic indicator of engine load.



The position of the rotary valve 3 of the auxiliary air regulator is governed by the bimetal element 1 which protrudes into the crankcase. The element is responsive to the temperature of the engine oil. This type regulator is used for type 3 models with manual shift. Models with automatic transmission and type 4 use an air regulator with an electric heating element which is described later in the book

1. bimetal element
2. shaft
3. rotary valve

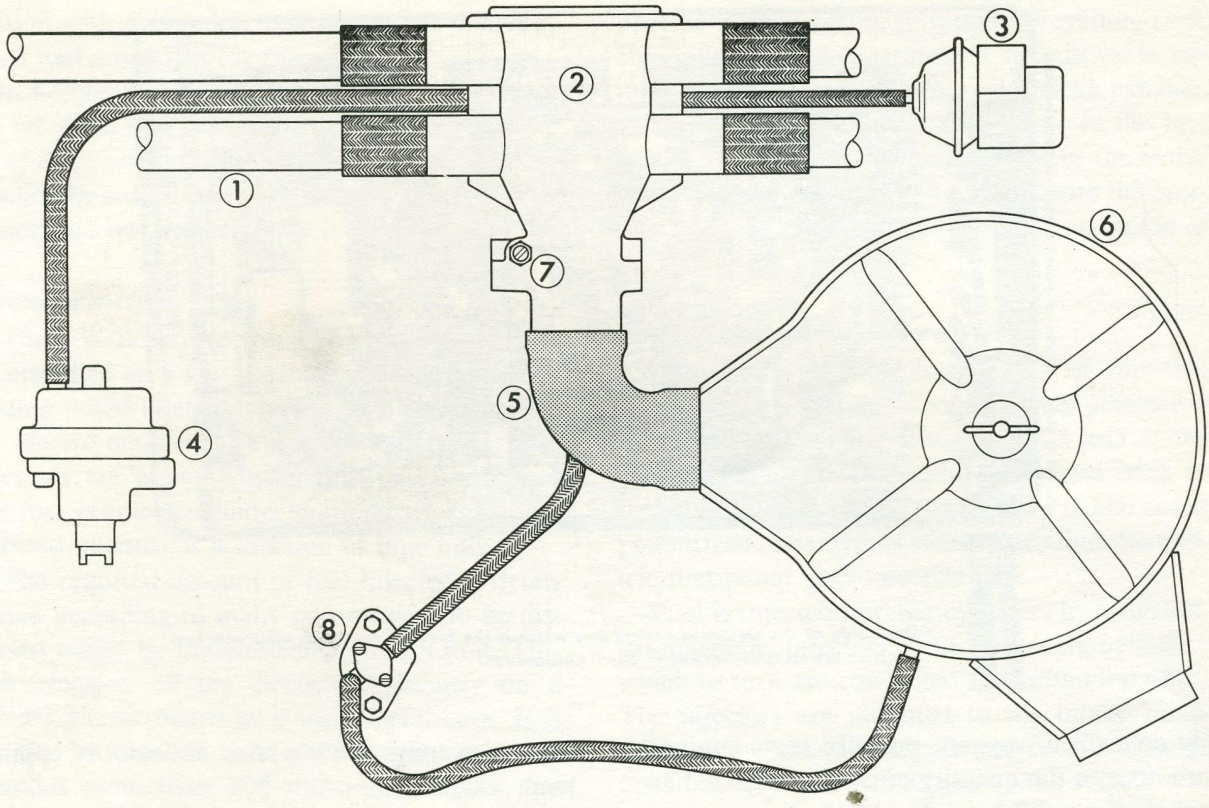


Diagram of air supply system. Fully explained in text

1. intake manifold
2. intake air distributor
3. pressure switch
4. pressure sensor
5. connecting elbow
6. aircleaner
7. idle air screw
8. auxiliary air regulator

The pressure switch 3 is responsive to the difference between manifold pressure and atmospheric (barometric) pressure.

The illustration shows the cable-operated throttle valve at the intake end of the air distributor. This throttle is completely closed at engine idle. The air system for the idle range actually is a separate by-pass system which terminates behind the throttle valve as shown. Idle speed adjustment is with air adjuster screw 7 which varies the by-pass passage area.

The amount of extra air required for cold starting and warmup is regulated by the auxiliary air regulator 8 situated right next to the ignition distributor. The air regulator contains a rotary valve which is operated by a bi-metal spring which protrudes into the crankcase and is responsive to the crankcase temperature. It is purely mechanical and not connected to the computer. At −30° C (−22°F) it is wide open. At +50° C (122° F) it is fully closed.

ELECTRICAL PART

The accompanying diagram shows the electrical part of the system. The electronic control unit 4 is the most important part of the system. It receives the vital signals from the various sensors and instantly decides on the appropriate action for the prevailing conditions.

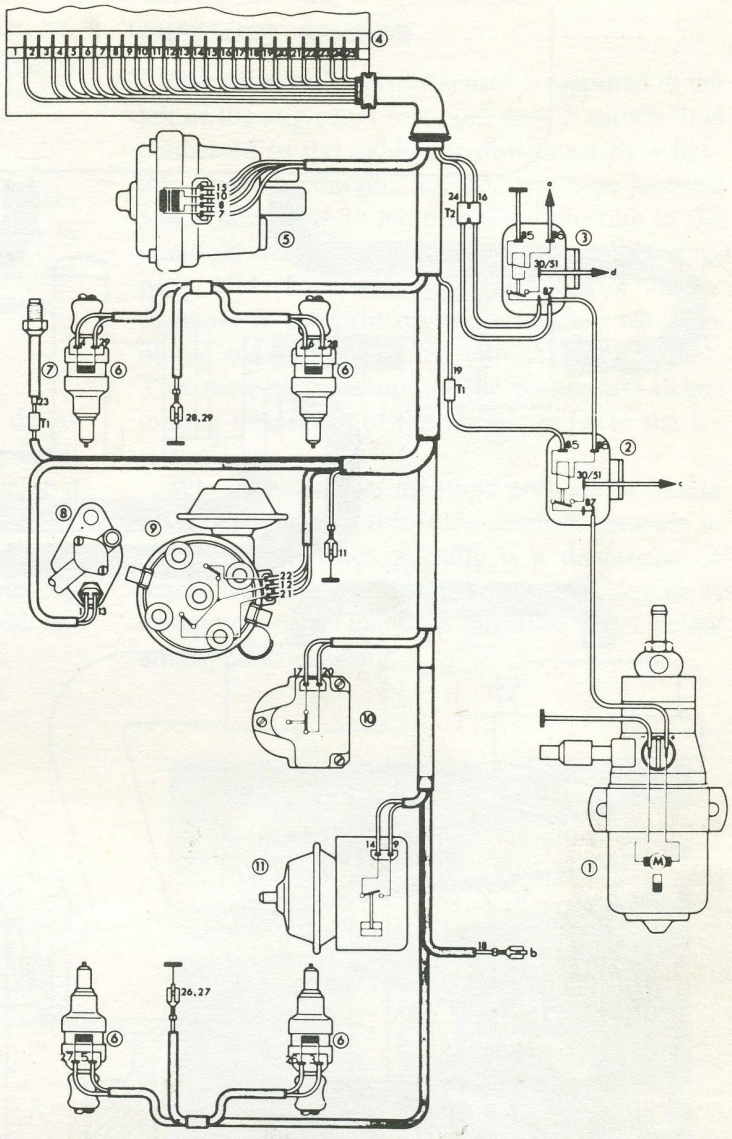
The computer is connected to the various members of the system through a wire harness and it can be disconnected by separating the 25 prong plug.

When the ignition is switched on the control unit receives current direct from the battery via relay 3. This relay also controls the fuel pump 1 which normally receives its current via pump relay 2 only when the engine is running.

When the ignition is switched on, a time switch in relay 3 allows pump 1 to operate for about 1 to 2 seconds.

The various components of the system can be seen in the illustration.

Diagram of electrical part of fuel injection system



1. electric fuel pump
2. pump relay (relay II)
3. voltage supply relay (relay I)
4. electronic control unit
5. pressure sensor
6. electro-magnetic fuel injectors
7. temp. sensor II (cylinderhead)
8. temp. sensor I (crankcase)
9. ign. distr. with trigger contacts
10. throttle valve switch
11. pressure switch

a. wire to ign/starter switch
b. wire to starter solenoid terminal 50
c. wire to terminal 30
d. wire to pos. battery terminal
T_1 wire connector
T_2 wire connector

The *pressure sensor* situated to the left of the engine is responsive to manifold pressure (i.e. absolute pressure, actually a depression or partial vacuum) and gives its signal accordingly.

The *pressure switch* monitors the pressure differential between intake air distributor and atmospheric pressure and controls the enrichment of the mixture at wide throttle openings.

The *throttle valve switch* cuts the fuel supply to the cylinders completely in a certain rpm range when the vehicle is decelerating.

These components will be discussed in more detail later on.

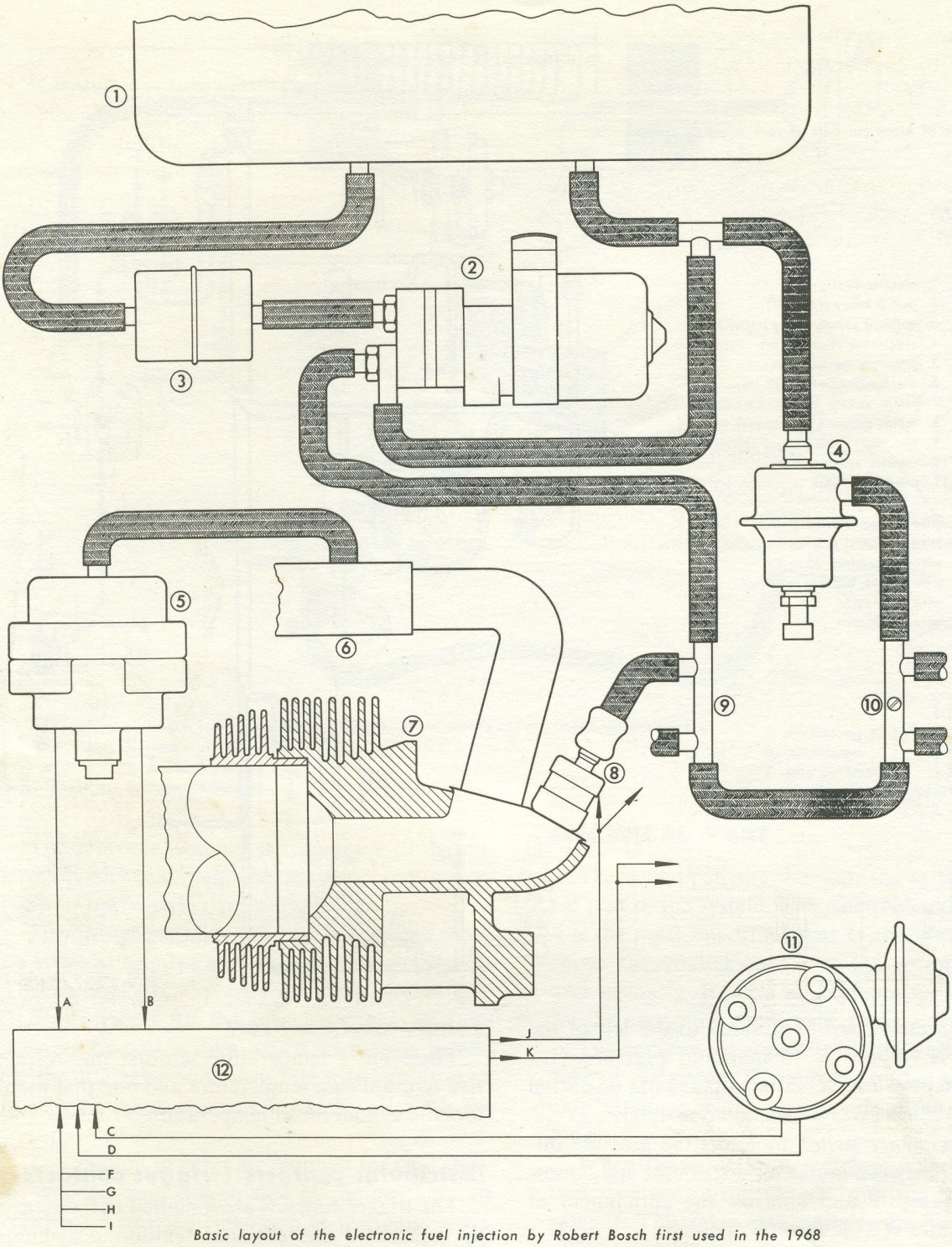
Temperature sensors

There are 2 temperature sensors: one responsive to crankcase temperature and one that monitors the cylinderhead temperature.

Distributor contacts (trigger contacts)

The trigger contacts are mounted in the base of the otherwise conventional ignition distributor. These contacts give the signals as to when and where fuel has to be injected. In addition, they also serve as engine speed (rpm) sensors.

The signals of these different members of the system are fed into the control unit which instantly digests them and decides on the correct



Basic layout of the electronic fuel injection by Robert Bosch first used in the 1968 Variant and fastback sedan

1. fuel tank
2. fuel pump
3. fuel filter
4. pressure regulator
5. pressure sensor
6. intake air distributor
7. cylinderhead
8. injectors
9. fuel line (left)
10. fuel line (right)
11. ign. distributor
12. electronic control unit

A and B. signals from pres. sensor
C and D. signals from trigger contacts

F. signal from temp. sensor
G. signal from throttle switch
H. signal from pressure switch
I. signal from starter
J. signal to injectors 1 and 4
K. signal to injectors 2 and 3

commands. Since the procedure is electronic, action can be considered instantaneous, practically without delay.

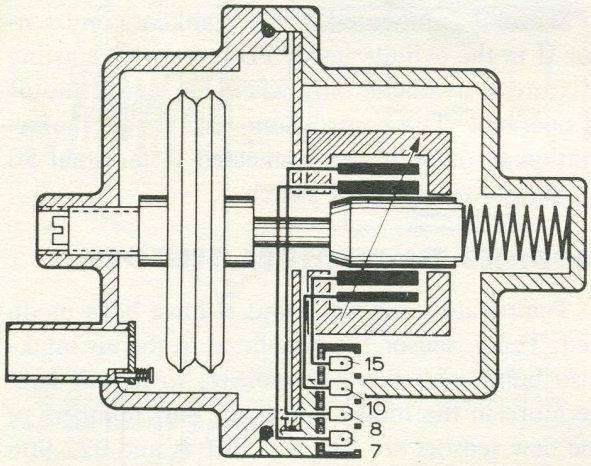
Testing

Special testing equipment is required for checking out the various components of the system in case of trouble. A detailed description of the complete testing procedure will be given later.

BASIC FUEL QUANTITY

The basic fuel quantity requirement is determined by engine speed (rpm) and engine load; it is logical that when the engine has to develop a lot of power and runs fast that it needs more fuel.

The information on engine load is given by the pressure sensor, and engine speed is indicated by the distributor trigger contacts as mentioned before.

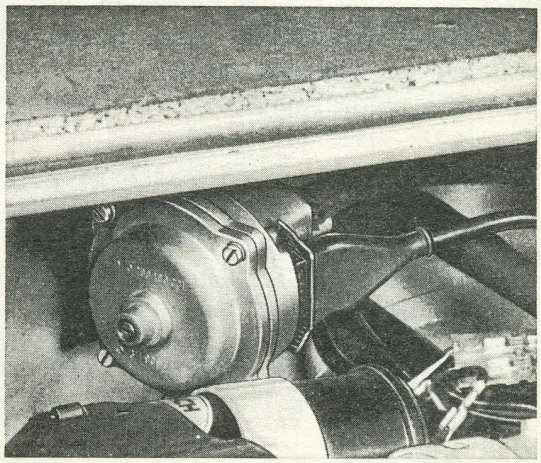


Sectional view of pressure sensor. The pressure sensor is responsive to absolute manifold pressure. Pressure variations are converted into electrical impulses. These signals are fed into the electronic control unit

PRESSURE SENSOR

The manifold pressure sensor is mounted to the left of the engine. A sectional view is shown. It is connected to the intake air distributor by a flexible hose. It contains a barometer type aneroid which according to the prevailing pressure in the manifold moves a cylindrical armature in a magnetic field. The subsequent variations of the inductance in the primary and secondary windings of the transducer are fed into the control unit. This then becomes one of the parameters determining the length of the electric pulse to the injectors.

When we speak of manifold pressure, it should be understood that this is the absolute pressure in the manifold which actually is a depression or partial vacuum. Inasmuch as the VW engine is unsupercharged, manifold pressure stays below atmospheric pressure.

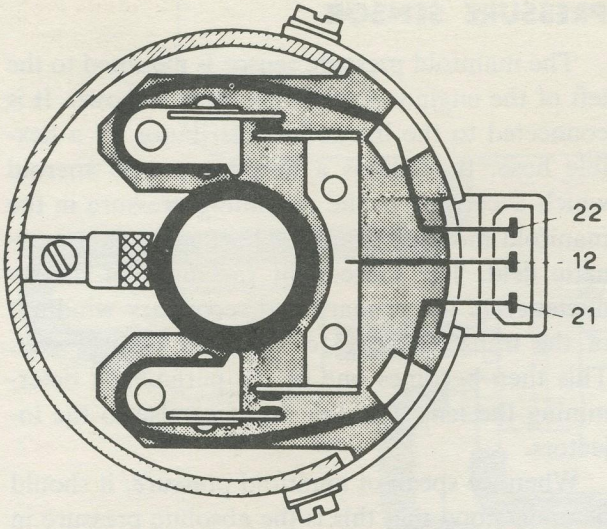


The manifold pressure sensor is mounted to the left of the engine

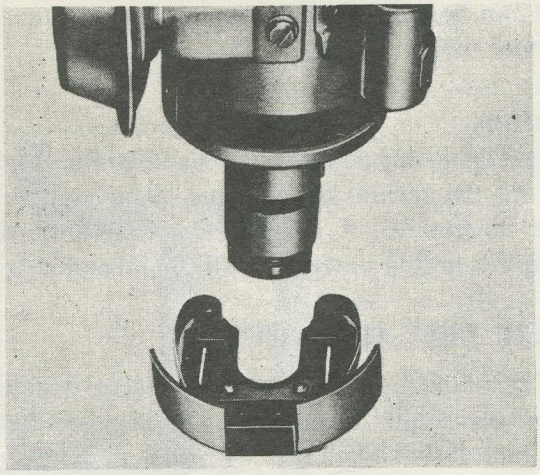
NEW TYPE PRESSURE SENSOR

A new type pressure sensor is used for the latest models. A sectional view is shown on page 52.

The armature is carried in two leaf springs and endwise movement for all practical purposes can be considered frictionless.



The ignition distributor trigger contacts signal engine speed (rpm) into the control unit. They also determine when and where fuel injection has to take place. The trigger contacts are mounted on a second breaker plate as shown in the opposite illustration



The trigger contacts are mounted on a second breaker plate as shown. They are operated by a single lobe cam and there is no provision for adjustment. When worn, assembly must be replaced

DISTRIBUTOR CONTACTS

The trigger contacts are mounted on a second breaker plate in the ignition distributor. The two contact sets are spaced 180° apart and are operated by a single lobe cam. No adjustment is provided and when the contacts are worn they must be renewed.

Although engine rpm and load determine the basic fuel requirements some further corrections are necessary. Factors such as mixture enrichment for cold starting, full load enrichment, fuel shut off on the overrun (deceleration) and temperature fluctuations also must be taken into account.

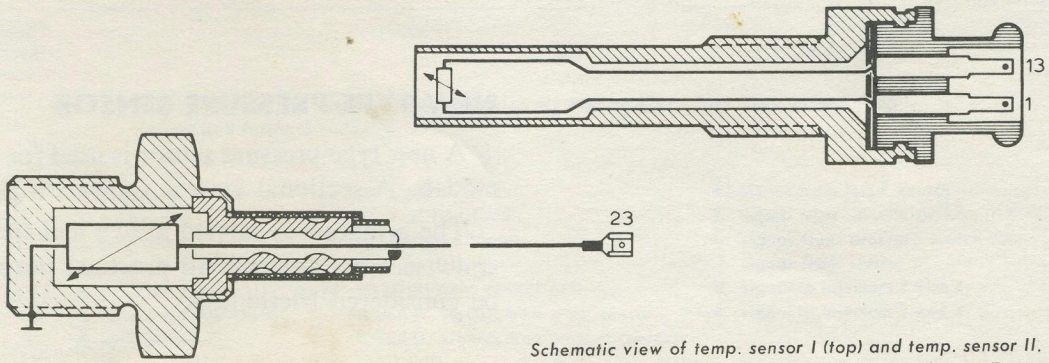
Temperature sensors

The temperature sensors I and II are shown in the accompanying illustrations. When the engine is started up from cold, extra fuel enrichment is required and this information is supplied by these sensors.

Sensor I is mounted in the crankcase and sensor II in the cylinderhead. The extra rich starting mixture is available only when the starter motor is operated. The control unit receives this information through a wire connected to terminal 50 on the starter solenoid switch.

MODIFIED TEMPERATURE SENSORS

Temperature sensors I and II have been modified. Temp. sensor I is now fitted in the air intake distributor and thus is responsive to the air temperature in the intake manifold. Part numbers of the new sensors are 311 906 081 A and 022 906 041.

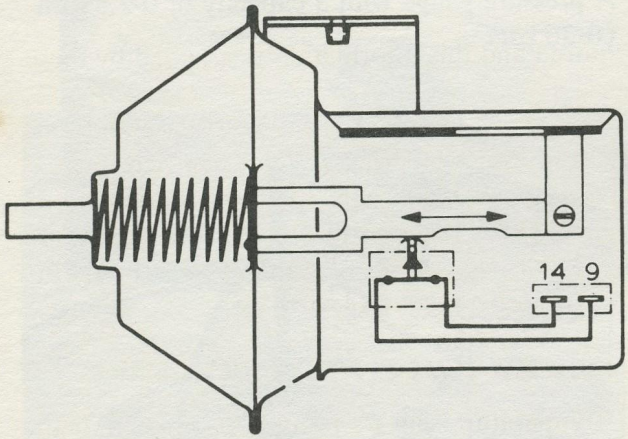


Schematic view of temp. sensor I (top) and temp. sensor II. Temp. sensor I is fitted on top of the crankcase. Temp. sensor II is mounted in the cylinderhead. Different type sensors are used in the later types

PRESSURE SWITCH

The pressure switch signals the need for extra fuel enrichment under full load (wide open throttle) conditions. The pressure switch is connected to the intake manifold by a short hose. The spring-loaded diaphragm operates a pair of contacts. Under full throttle conditions when absolute manifold pressure approaches atmospheric pressure, the diaphragm moves to the right which closes the contacts in the switch. A signal is then induced to the control unit indicating the need for immediate mixture enrichment.

This type pressure switch is used only on earlier models. Its duty was first taken over by a modified pressure sensor and for the 1972 models by a new type throttle valve switch. These and other modifications are covered later in the book.



Diagrammatic view of pressure switch used on early models. This switch is responsive to the pressure differential between atmospheric and manifold pressure

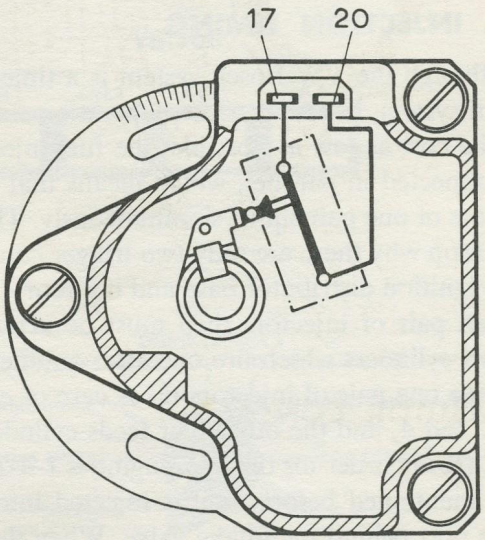
THROTTLE VALVE SWITCH

When the foot is lifted off the accelerator and the vehicle is decelerating (coasting in gear), no fuel is required, and it is the duty of the throttle valve switch to shut off the fuel supply to the cylinders completely. Fuel shut-off during deceleration saves fuel and also is a big help in keeping exhaust gas emissions within limits.

The throttle valve switch is a micro switch mounted on an adjustable base plate on the throttle valve assembly. It is activated by a lever on the throttle valve shaft.

When the engine speed is above 1800 rpm and the foot is lifted off the accelerator, the throttle valve switch overrides all other commands and signals for fuel shutoff. When the engine rpm has dropped to about 1250, its own signal is overridden and fuel supply is restored to ensure smooth pickup when needed.

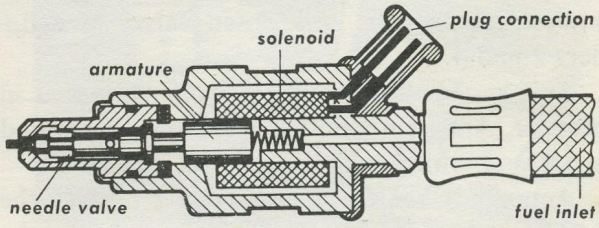
NOTE: on some export models, the fuel shut off feature is not used.



Early type throttle valve switch with fuel shut off. Later types have been modified. On some models the fuel shut off feature is not used

INJECTOR UNIT

Each cylinder has its own injector. The electro-magnetic injector consists of a valve assembly with an inwardly opening single orifice nozzle with a pintle type needle valve. The movable core of the solenoid assembly is attached to the end of the valve stem.



Schematics of the electro-magnetic fuel injector. There is one injector for each cylinder

When no current is supplied to the injector the needle is pressed on its seat by a small spring. When current is supplied to the solenoid, the needle is lifted very slightly, about .15mm (.006 in.) and fuel flows out through a calibrated open-

ing. The front end of the needle valve assembly has a small projection for efficient spray action of the ejected fuel.

The amount of fuel injected depends on the length of the electric impulse determined by the control unit, and as we have seen before is directly proportional to the time factor.

FUEL INJECTION TIMING

Although the VW Bosch system is a timed injection system, in order to keep operation simple, and the cost as low as possible, the fuel injectors are connected in parallel, which means that both injectors of one pair squirt simultaneously. This is the reason why there are only two trigger contacts in the ignition distributor base and not four.

Each pair of injectors then must be arranged for two cylinders which fire one after another. In this case one pair of injectors takes care of cylinders 1 and 4, and the other pair feeds cylinders 2 and 3 (firing order for the VW engine is 1-4-3-2).

As mentioned before, fuel is injected into the intake port behind the intake valve. When the intake valve of No. 1 cylinder opens, fuel is injected through the open intake port of this cylinder. But since injectors 1 and 4 are connected in parallel and inject simultaneously, fuel will also be injected behind the intake valve of No. 4 cylinder which is still closed. In the latter case the fuel is being "stored" until such time that the valve opens 180 crankshaft degrees later.

Operation is identical for cylinders 3 and 2. Summing up: fuel is injected through the open intake valves of cylinders 1 and 3, while fuel is squirted against the still closed valves of cylinders 2 and 4.

This system has proved to work very well in practice. Apparently timing of the injection period is not very critical with this indirect system.

Actually, when the engine is running fast, the fuel does not remain "stored" for long behind the rapid opening and closing intake valves of cylinders 2 and 4. All that happens is that the back of these valves run slightly wet.

Modified injection timing for type 3 engines

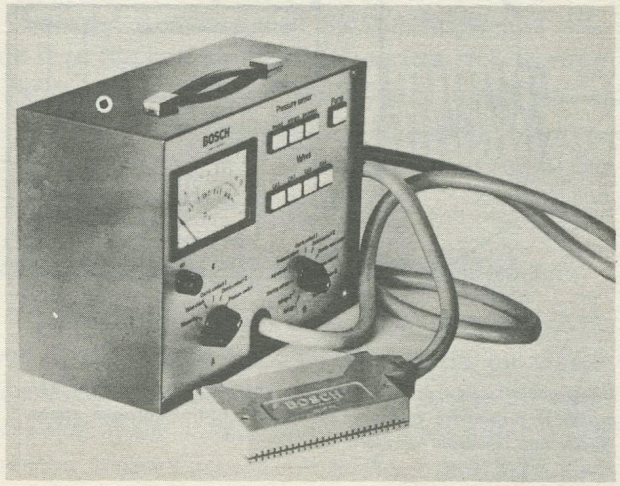
Starting with the 1972 model year, fuel injection timing has been changed for type 3 engines. A modified trigger contact unit changes the injection timing in such a way that fuel is injected behind the closed intake valves for all four cylinders. In other words, fuel is no longer injected through the open intake valves of cylinders 1 and 3 as described above. At this writing, this modification is used only on type 3 engines.

CHECKING THE FUEL INJECTION SYSTEM

Special equipment is necessary to check out the system. The following appliances are necessary for a complete testing procedure:

Tester Bosch EFAW 228 (or 193 with adapter)

A tachometer for checking engine speed (rpm)
A stroboscopic timing light
A pressure gauge with a capacity of 0-2.5 atm (0-36 psi)

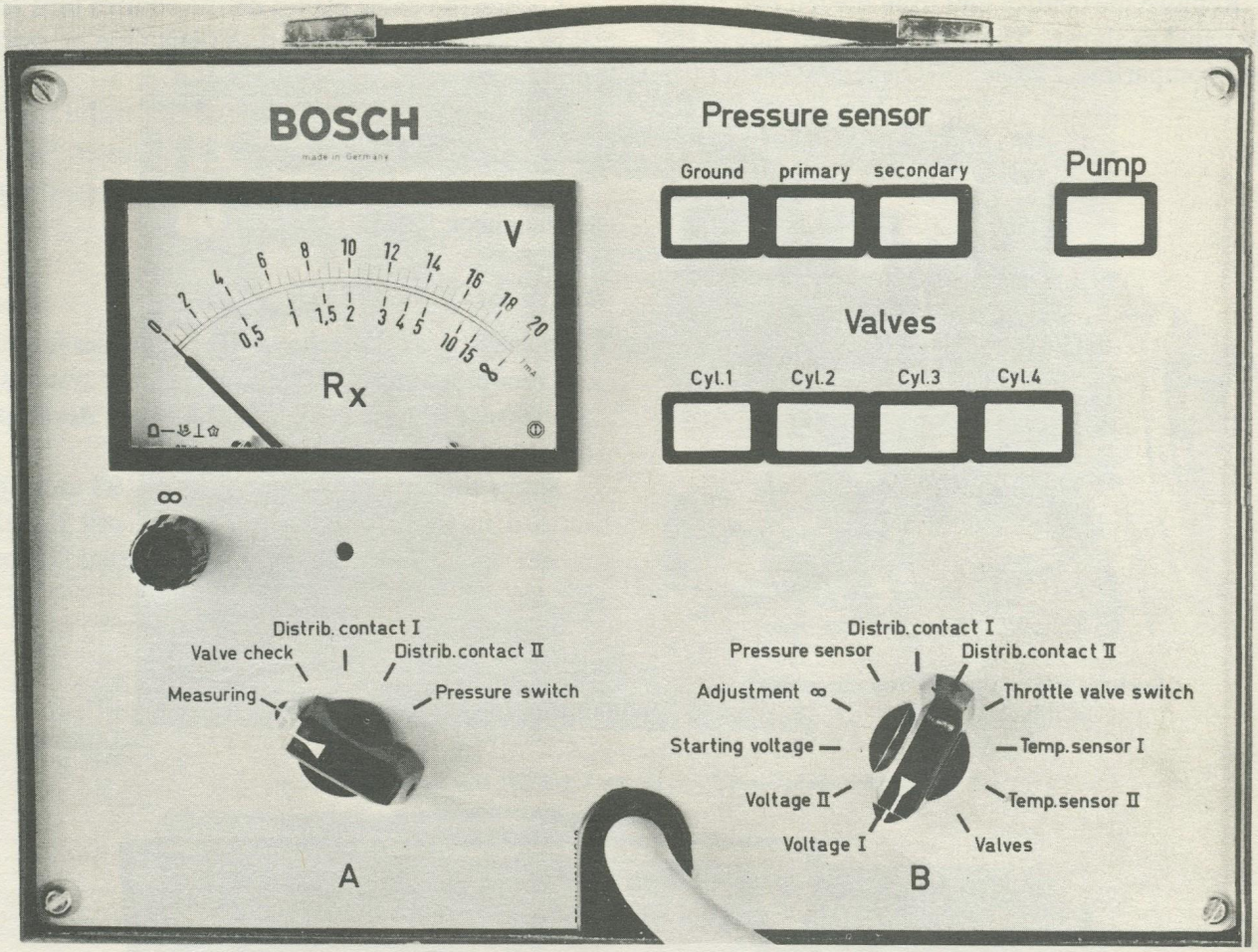


Early type Bosch tester EFAW 193. A close up of the dial is shown on opposite page. For checking out late F.I. systems, this tester must be used together with an adapter or use tester 228

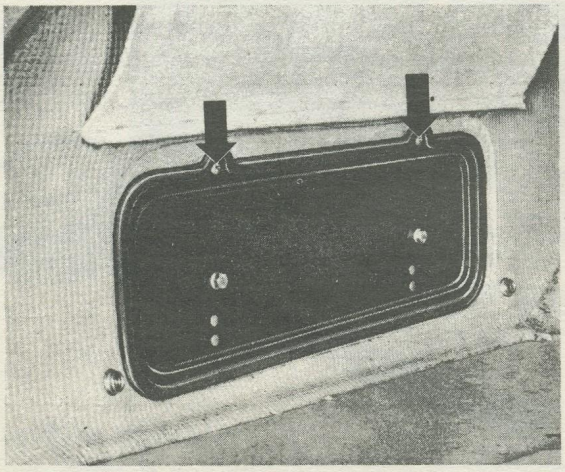
The most important piece of equipment is the special Bosch tester EFAW 228 S 10. With this tester all the sensors, the fuel pump and injectors can be tested according to a set sequence as set out in the check list.

The test also includes checking the pressure in the fuel loop line and checking the injectors for leaks. Very important is that all functions and components are checked.

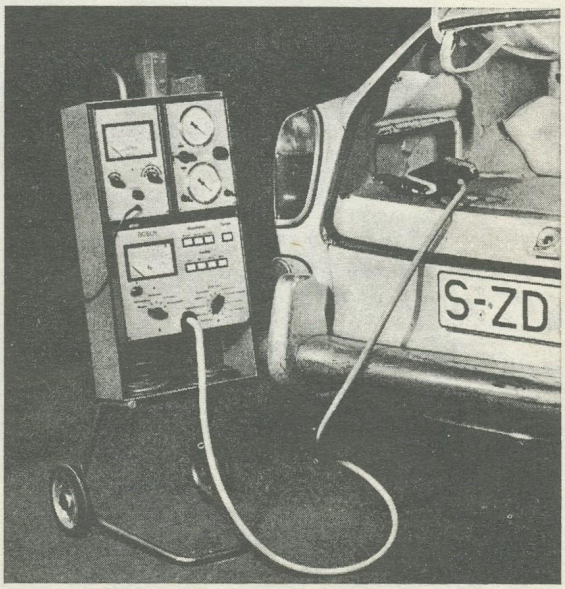
Before starting the testing procedure be sure that the ignition is switched off in order that the control unit is free of current.



Dial of early type Bosch tester EFAW 193. To check out later systems, tester EFAW 228 is used or 193 can be used with adapter EFAW 243

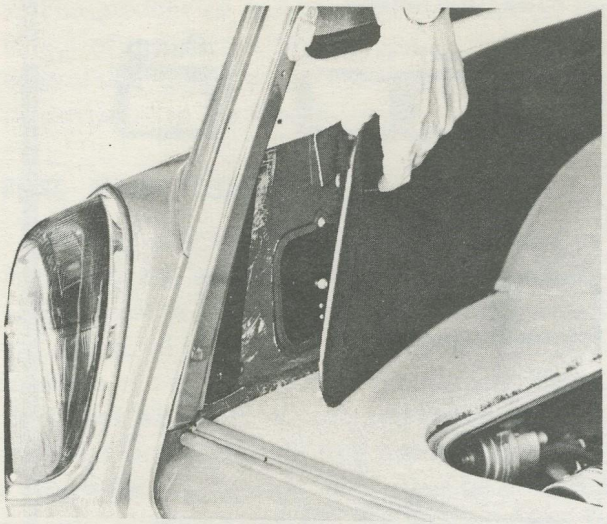


Trim removal in luggage compartment of the fastback. The two arrows point to the retaining screws of the electronic control unit



A convenient checking unit in which all the necessary test instruments are combined

Remove the control unit from the left rear quarter panel as shown. The trim on the left side of the rear compartment must be loosened first as shown.



Loosening trim on left side of rear compartment

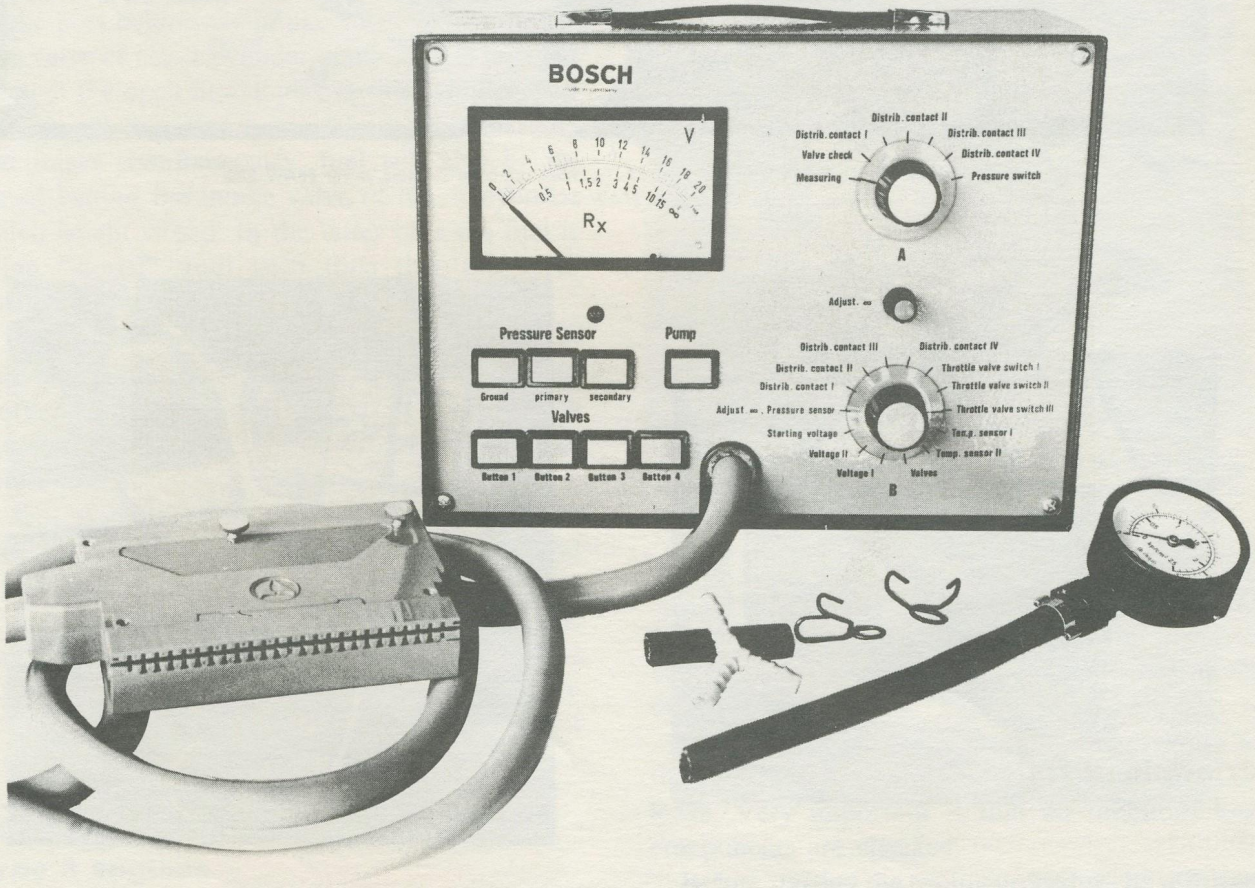
Loosen the cable clamp on the control unit and slide end cover out toward the left (see arrow in illustration).

Pull out the 25 prong plug and be careful to pull it out straight. Insert plug into Bosch tester. Switch on the ignition and test all components according to the check list.

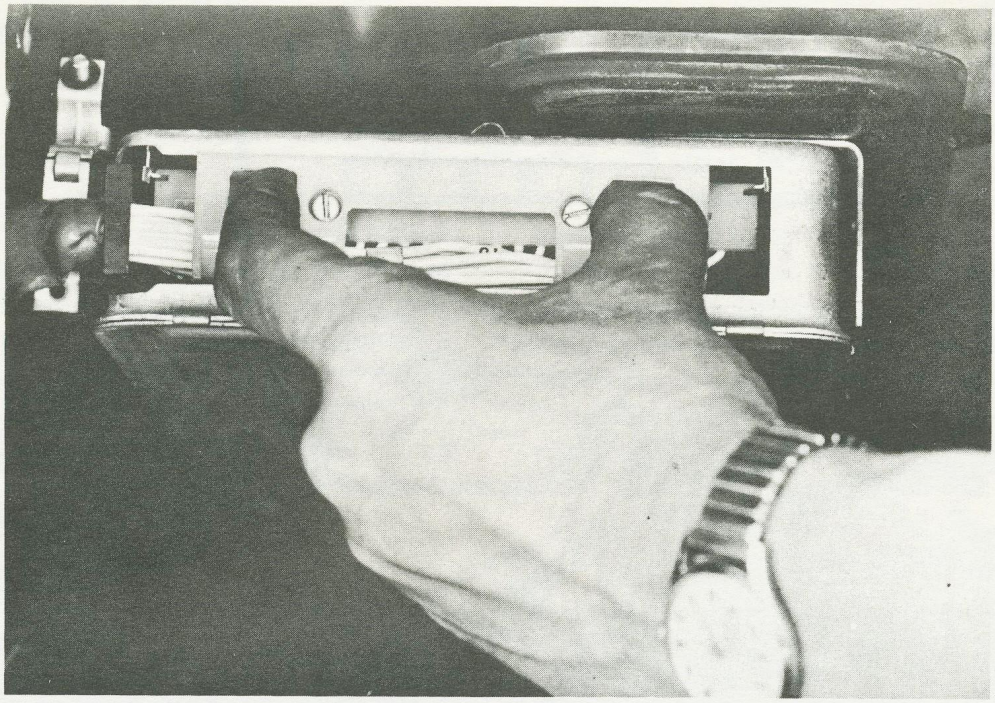
NEW BOSCH TESTER

Inasmuch as there have been considerable detail modifications in the later electronic systems, a new Bosch tester EFAW 228 has been developed for checking out the new systems.

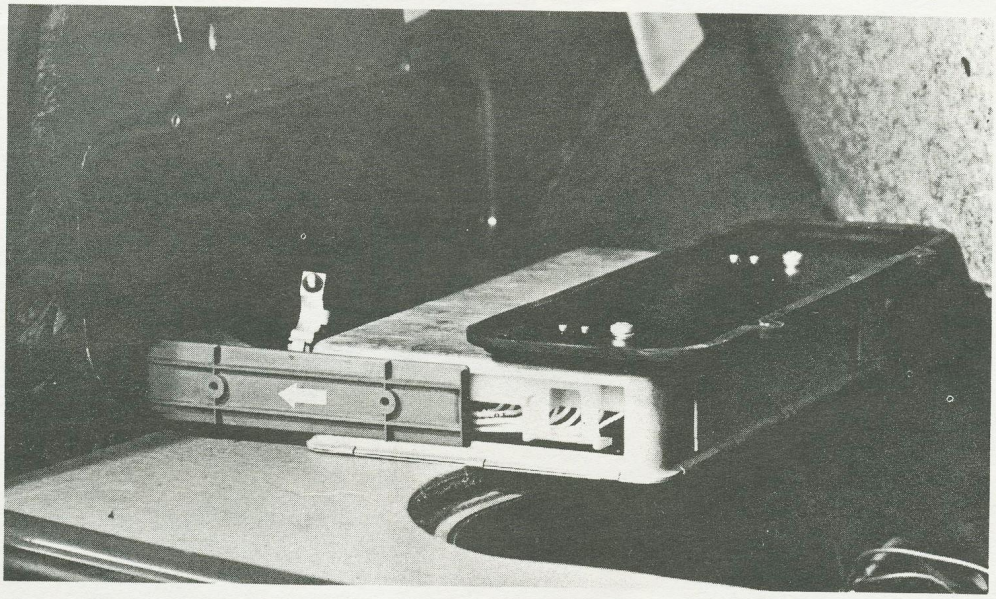
Shops that have the older EFAW 193 tester described in the preceding pages can still use this model in conjunction with the special adapter EFAW 243.



Latest type Bosch EFAW 228 tester with pressure gauge



Pulling multiple plug out of unit. Be sure it is pulled out straight

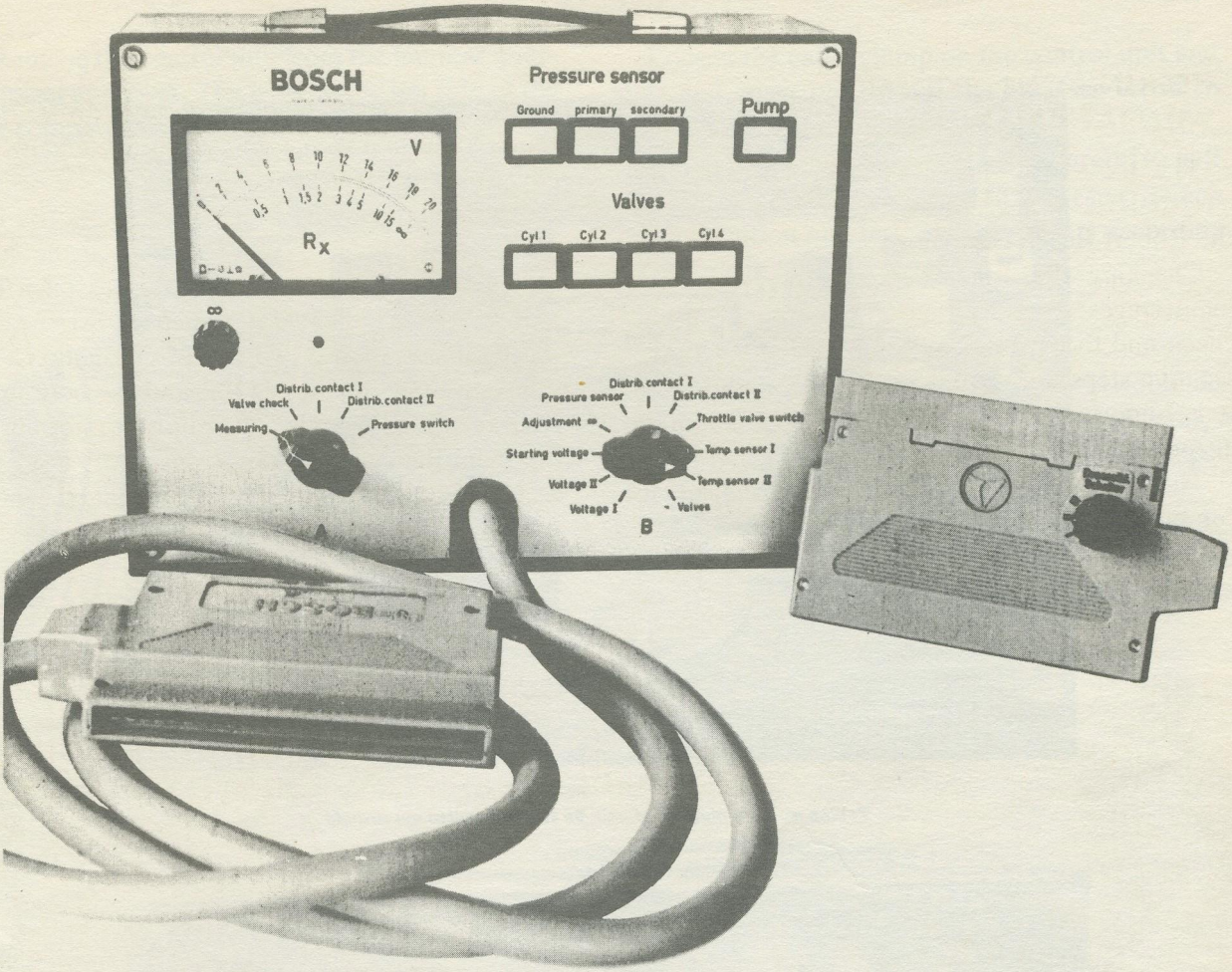


End cover can be removed after cable clamp has been opened up

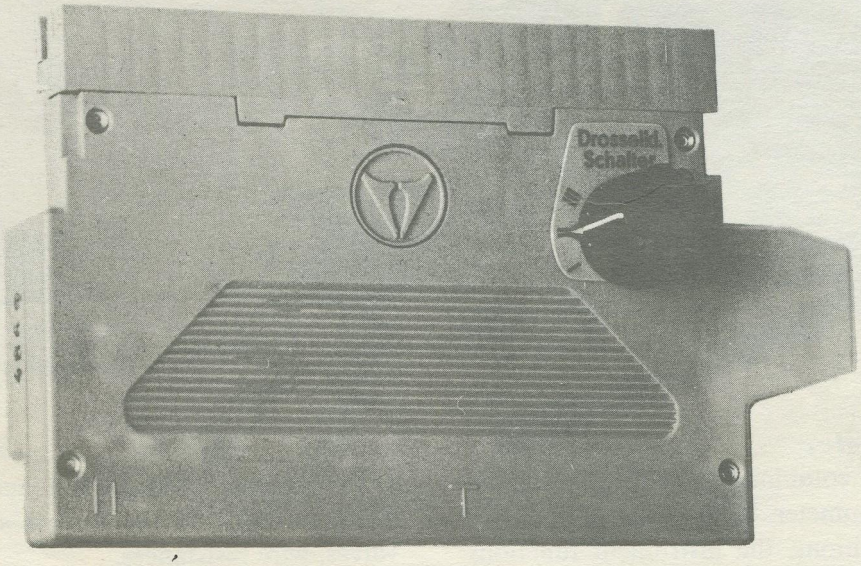
Principle of tester

The tester is a combination of a sophisticated voltmeter and ohmmeter. With switch B in any of its first three positions, the instrument functions as a voltmeter checking the voltage supply of the system.

In the other positions it functions as an ohmmeter in checking the various switches, sensors, valves, wire resistances.



The older type EFAW 193 with adapter 243



Adapter EFAW 243 is necessary for checking out the latest systems when only the older type EFAW 193 is available. The adapter has a switch for extra positions (Throttle Valve)

CHECKING THE SYSTEM SYSTEMATICALLY

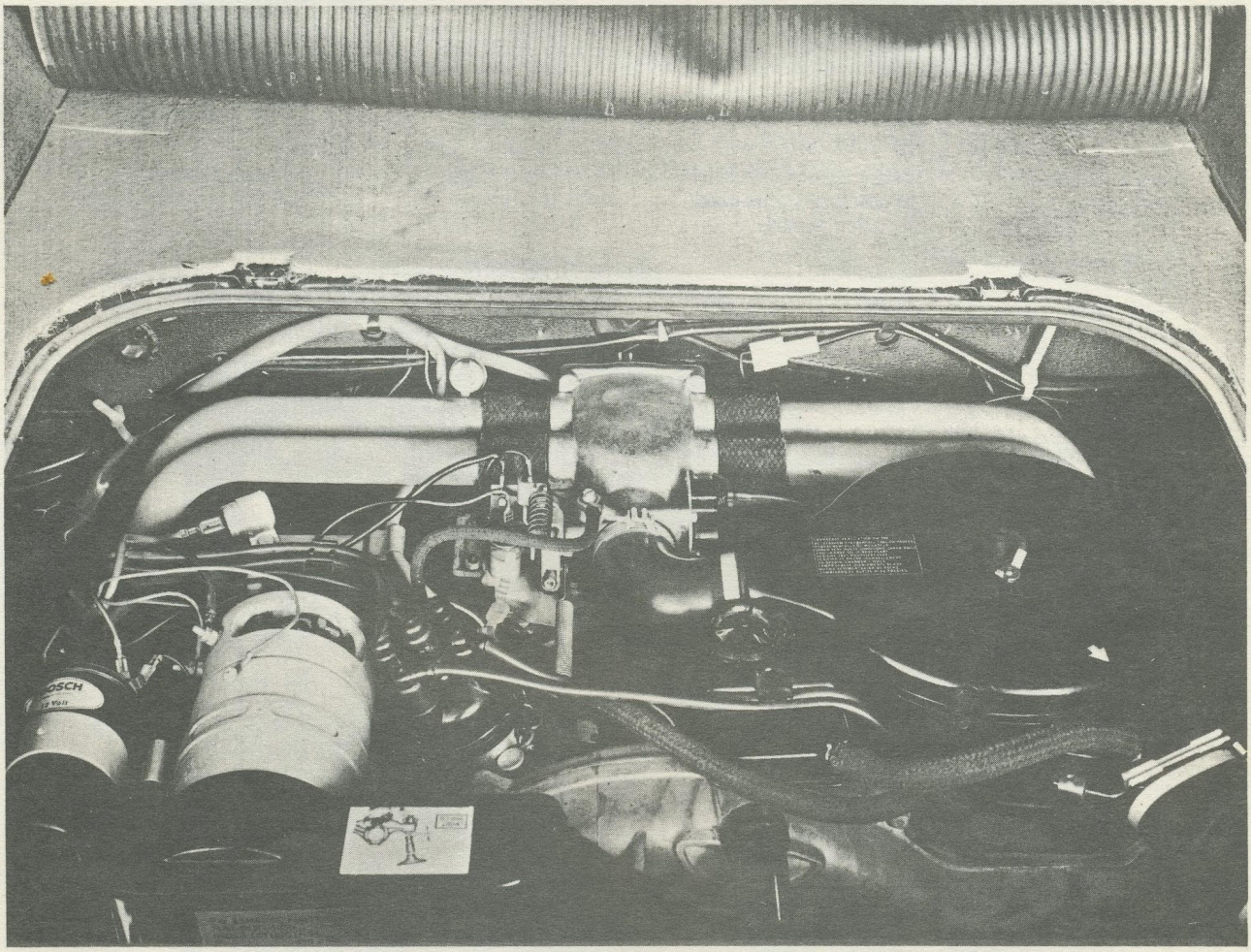
The most vital instrument for checking the electronic system is tester EFAW 228 made by the Robert Bosch company.

Checking the system is performed in three main stages: the electrical check, the hydraulic check and the dynamic check. All in all, 19 consecutive steps are set out in the following tables. It is important that these steps are taken in sequence and that none are omitted.

The trouble shooting chart must be used in combination with the first chart. The trouble shooting chart lists the most likely causes of failure when the tester readings do not tally with the required normal values and suggests the best remedy which is given in bold type.

The accompanying illustration shows the face of Bosch tester EFAW. The use of the main switches A and B and of the various push buttons is clearly indicated in the check list.

The dial scale has two sets of graduations: the top for voltage readings (V), and the bottom for resistance readings (R). Readings do not always represent the actual values. Consult the test chart as to how the various readings should be interpreted.



The fuel injection engine in a 1969 Variant. The absence of bulky carburetors and broad air cleaner makes access to engine much easier. Especially the replacement of spark plugs is much more convenient. This particular engine is coupled to an automatic transmission. 1969 was the first year that the combination of fuel injection engine and automatic transmission was used

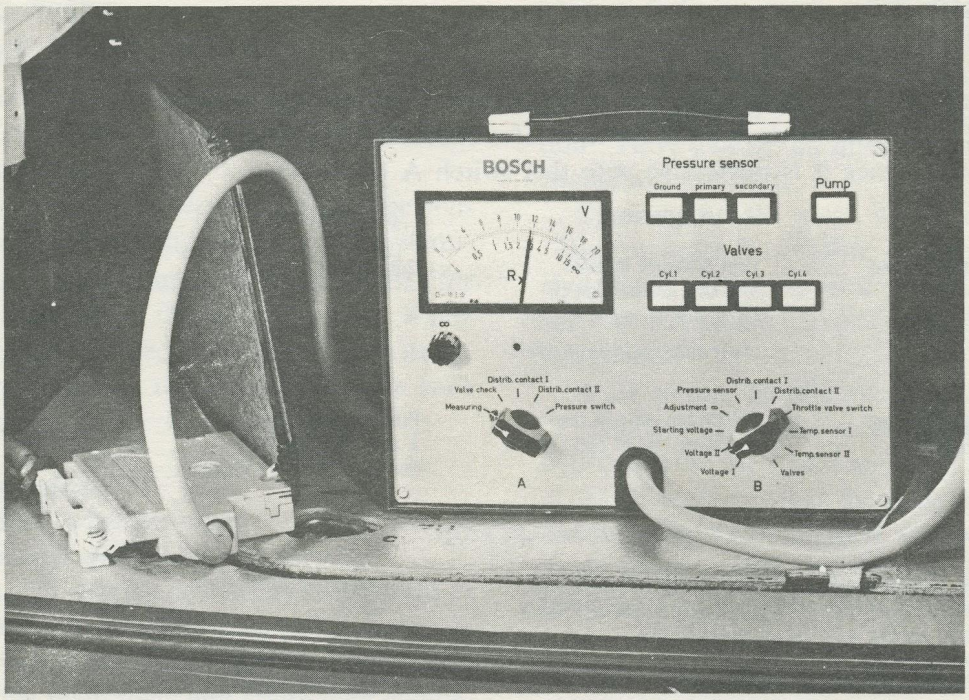
A- Ohmeter
B- Voltmeter

CHECK LIST
ELECTRICAL CHECK (SWITCH A IN POSITION "MEASURING")

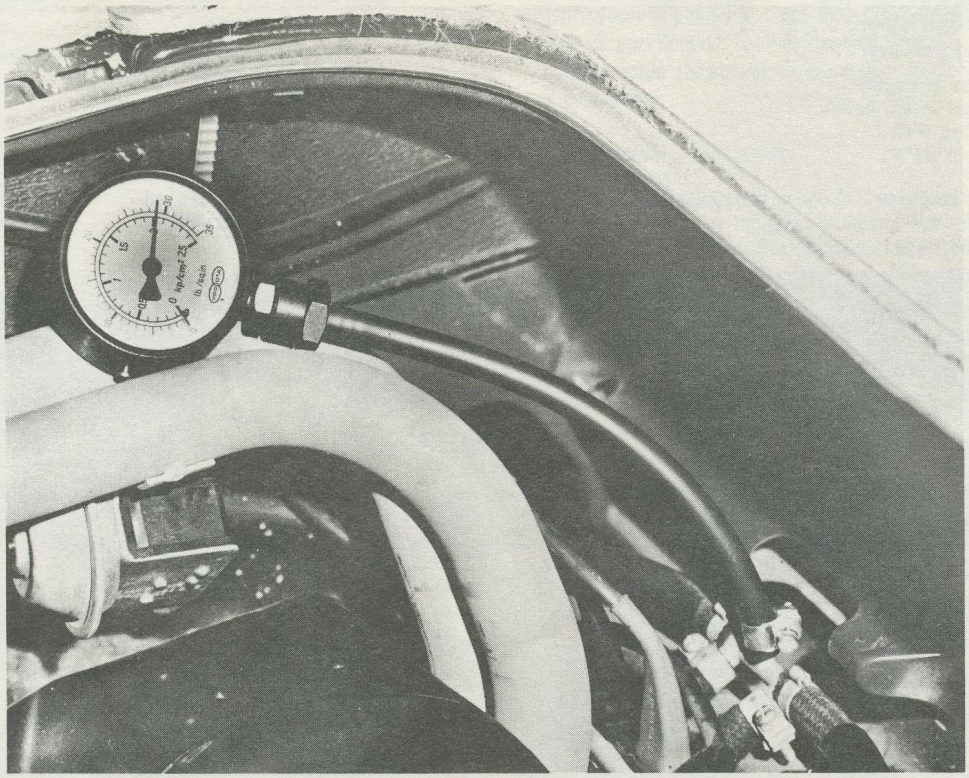
Checks for later models (as of Aug '69) shown in italics

STEP	POSITION OF SWITCH B	OPERATE	MEASURING	DIAL READING (NOMINAL VALUE)
1.	Switch B in position "Voltage I"	Switch on ignition and leave it on throughout entire test procedure	Voltage supply to control unit (computer)	11-12.5 shown on dial (11-12.5 Volt actual value)
2.	Switch B in position "Voltage II"		Voltage supply to control unit	11-12.5 shown on scale (11-12.5 Volt actual value)
3.	Switch B in position "Starting voltage"	Operate starter for a short time	Voltage at terminal 50 of starter solenoid switch	9.5-12 shown on dial (9.5-12 Volt actual value)
4.	Switch B in position "Adjustment (infinite)	Tester is set to ∞ (infinite)	infinite by switching to pressure sensor	∞ (infinite) shown on dial
5.	Switch B in position "Pressure sensor"	Push button marked "Ground"	Resistance between pressure sensor windings and ground	Resistance ∞ (infinite) shown on dial
6.	Switch B in position "Pressure sensor"	Push button marked "Primary"	Resistance of primary windings of pressure sensor	.8-1.2 shown on scale actual value about 90 Ω)
7.	Switch B in position "Pressure sensor"	Push button marked "Secondary"	Resistance of secondary windings of pressure sensor	3-4 shown on scale (about 350 Ω actual value)
8.	Switch B in position "Distr. contact I"	Rotate ignition distributor by operating starter motor for a few seconds	Resistance of trigger contacts of group	alternately between 0 and ∞ (0 Ω to ∞ Ω actual)
9.	Switch B in position "Distr. contact II"	Rotate ignition distributor by operating starter motor for a few seconds	Resistance of trigger contacts of group	alternately between 0 and ∞ (0 Ω to ∞ Ω actual value)
9a.	*Throttle valve switch I* *Throttle valve switch II*	Slowly depress acc. pedal	Operation of mixture enrichment	Needle swings between 0 and ∞ about 10 times
10.	Switch B in position "Throttle valve Switch III"	Throttle valve in idle position (closed)	Resistance of contacts in throttle valve switch	0 shown on scale (0 Ω actual value)
11.	Switch B in position "Throttle valve Switch III"	Throttle valve almost closed (about 2°)	Resistance of contacts in throttle valve switch	∞ shown on scale (∞ Ω actual)
12.	Switch B in position "Temp. sensor I" (in crankcase) *(Intake air Distr.)*	.....	Resistance of temperature sensor	3 shown on scale (about 300 Ω actual. Strongly influenced by temp. Value decreases with increasing temp.)
13.	Switch B in position "Temp. sensor II" (cylinderhead)	.....	Resistance of temperature sensor	2-3 shown on scale (about 2500 Ω actual. Strongly affected by temp Value decreases with increasing temp.)
14.	Switch B in position "Valves" (fuel injectors)	Operate buttons Cyl. 1 Cyl. 2 Cyl. 3 Cyl. 4	Measuring resistance of Injector windings and feed cables	about 2-3 shown on dial (about 2.4 Ω actual value)

NOTE: Check to see that the injectors are connected correctly. The gray protective caps should be at the rear and the black ones in front. Also check the secure installation of all the protective caps.



Checking the voltage supply to control unit with Bosch tester. Switch A is in position Measuring. *With switch B in position* Voltage I or Voltage II, *tester should read 11-12.5 on dial*



For the hydraulic test the pressure gauge is connected to the fuel line T-piece as shown after the stop screw has been removed

HYDRAULIC TEST

Checking fuel injectors

For this test the pressure gauge must be connected as shown. Ignition must be switched on. Turn switch A on tester to "Valve check." (Position of switch B is immaterial since it is ineffective with this switch A position).

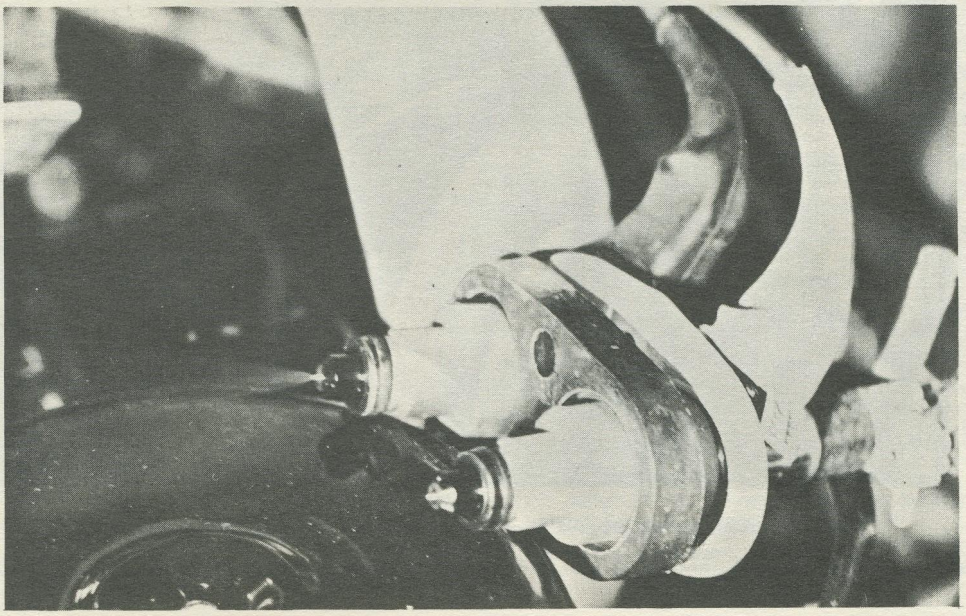
	OPERATE	MEASURING	DIAL READING
15.	Push button marked "Pump"	Fuel pressure in main loop line. Connection on right side on older models *Left side on later models*	2-2.2 atm. (28-32 psi)
16.	Push button marked "Pump" briefly	Check for leaks in the pressure line of fuel system	Pressure may drop to 1 atm. (15 psi, then decrease only very slowly

CHECKING COLD START VALVE AND TEMP. SWITCH

	1. Push button marked "Pump," operate starter briefly *2. Ground Temp. Switch connection* *a. Temp. in engine compartment above + 5° ± 5°C (41° ± 41°F)*	*Checking operation of Temp. Switch and Cold Start Valve*	*1. Pressure should not drop* *2. Cold Start Valve injects; fuel pressure decreases*
16a.	*Push button marked "Pump." Again operate starter briefly, but now with normal Temp. Switch connection* *b. Temp. in engine compartment below + 5° ± 5°C (41° ± 41°F)*	*Checking operation of Temp. Switch and Cold Start Valve*	*Pressure should decrease slowly*

NOTE: If there is suspicion that one or more injectors are defective, remove the injectors, push button marked "Pump" for fuel pressure build-up, then push buttons marked "Cyl.1," "Cyl.2," "Cyl.3," "Cyl.4" to visually check ejection spray. Be sure to catch ejected fuel.

Switch off ignition
Disconnect pressure gauge



Checking operation of injectors visually while cranking over starter motor

DYNAMIC TESTS (ALSO SEE TABLE BELOW)

The so-called dynamic tests are carried out with the control unit connected to the tester and with the engine running.

With these tests the battery must always be connected to prevent damaging the electronic systems.

Never use a quick charger as a start assist (for instance in cases where the battery is low). When a quick charger is used to charge the battery, temporarily disconnect the battery from the car's wiring system.

Starting engine

The engine (whether warm or cold) should always be started with wide open throttle.

After the cold starting device has been checked, there might be a possibility that the engine is flooded. In this case, disconnect the brown wire (87) from the main relay and crank over engine.

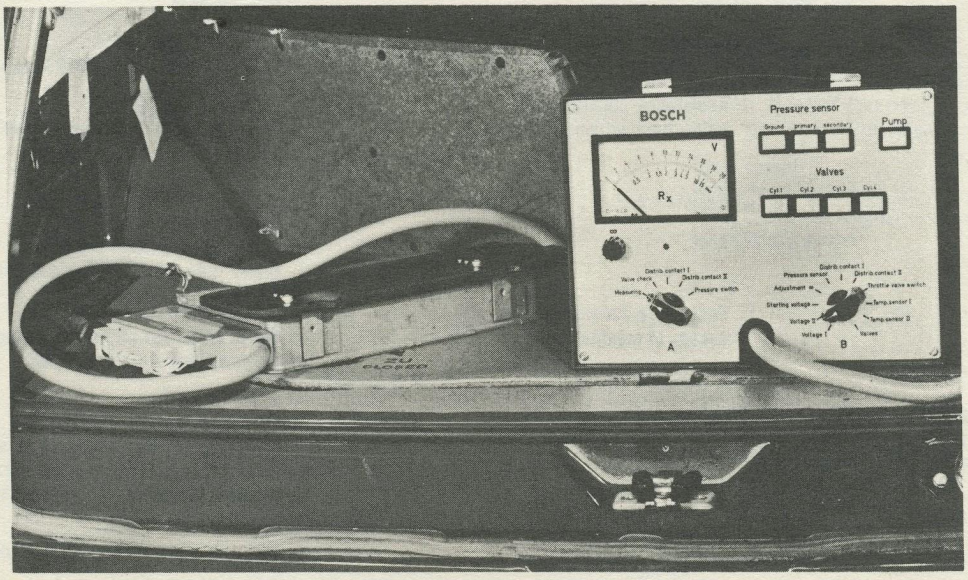
To start dynamic test, switch off ignition and connect plug of tester (with wire harness connected to it) to the control unit. Before starting engine, turn switch A to position "Distr. Contact I." Position of switch B is immaterial. In position "Valve Check" all injectors will be open and engine will not start.

Observe needle shift when switching from 'Distr. contact I" to "Distr. contact II." Deviation should not exceed about 2 graduations. If needle shift seems excessive, replace trigger contact holder as a unit.

With engine at idle speed turn switch A to "Pressure switch." The needle on the V scale must deflect toward the 13-20 region. If needle does not deflect it indicates that the pressure switch is not operating and that there is an open circuit. Remove electric plug and bridge the contacts. If tester now indicates 0, replace cable harness. Otherwise test pressure switch.

With the engine stationary, but ignition switched on, the needle on tester must show 2 to 5 on the V scale.

STEP	POSITION OF SWITCH A	OPERATE	DIAL READING (V SCALE)
17.	Switch A in position "Distr. Contact I" and "Distr. Contact II"	Let engine run at appr. 1500 rpm. Switch from "Distr. Contact I" to "Distr. Contact II" alternately	Needle goes in direction of max. deviation, then swings around a median value. When switching from Contact I to Contact II, the deviation from this average value should not be more than about 2 graduations
18.	Switch A in pos. "Pressure switch" (only for older cars up to Aug. '69)	a. Let engine run at idle speed b. Stop engine, then switch on ignition again	Needle should go just about fully to the right About 2-5 on V scale

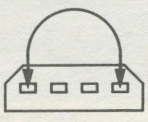


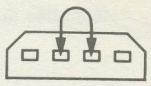
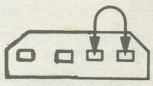
For the dynamic tests with the engine running the multiple plug of the tester is connected to the electronic control unit as shown

TROUBLE SHOOTING CHART

This chart gives the probable causes of failure when going through the check list. If the tester (EFAW 228) readings deviate from the nominal values, some additional testing procedures are given below. This chart to be used together with the regular check list.

STEP	TESTER READING	PROBABLE FAULT (Remedy given in bold type)
1 Voltage I	No reading	An open circuit between wire of relay I and control unit. Relay I defective. Ignition switch defective **Check if there is voltage at terminals 86, 30/51 and 87 of relay. Check if there is voltage at the terminals 86, 30/51 and 87 of relay. Check wire 16 from main relay to control unit. Wire 11 defective (no ground)**
	Voltage below 11 volts	Excessive contact resistance in wire 16, 11 or at the relay contacts **Check wire; replace relay I**
2 Voltage II	Test procedure as with step I above, but check wire 24	
3 Starting voltage	No voltage, but starter operative	Open circuit in wire from starter solenoid switch to control unit **Check wire 18**
	No voltage and starter inoperative	Ignition-starter switch defective. Open circuit in wires
	Voltage below 9 volts	Battery dead. Excessive voltage drop in wire from ignition-starter switch to terminal 50 of starter solenoid **Check voltage drop with voltmeter**
4 Adjustment to ∞	When needle of tester does not move to the end position, battery voltage is too low. Also see test for step I	
5 Pressure sensor short-circuited to ground	Resistance 0	Short circuit to ground at wire or at pressure sensor **Pull plug out of sensor and if tester indicates ∞ , replace sensor. If tester still indicates 0, wires 7, 8, 10 and 15 are shorted. Replace wire harness**
	Needle on tester below ∞ but not on 0	Insulation damaged **Check as described above**
6 Pressure sensor primary	Resistance considerably below nominal value of 90 Ω	Insulation damaged **Pull plug out of sensor and if tester indicates ∞ , replace sensor**
	Resistance 0	Short circuit to ground; short circuit in secondary windings **Pull plug out of sensor and if tester indicates ∞ , replace sensor**
	Resistance considerably in excess of nominal value of 88 Ω	High contact resistance **Check electrical plugs and wiring for corrosion and open circuit**
	Resistance ∞ Ω	Open circuit **Bridge outer plug terminals as shown.** **If tester indicates 0, replace pressure sensor** **If tester indicates ∞ , repair cable**



STEP	TESTER READING	PROBABLE FAULT (Remedy given in bold type)
7 Pressure sensor secondary	As with step 6 but with nominal value about 350 Ω	As with step 6, with resistance at ∞ , bridge the 2 plug terminals as shown 
8 Distributor contact I	Resistance larger than 0 Ω , but smaller than ∞ Ω	If needle of tester does not move when operating starter or remains in one spot (0 or ∞), heck connections, 12, 21 and 22 at distributor contacts **If contacts OK, replace distributor contact holder**
9 Distributor contact II	As above	As above
9a. *Throttle valve switch I* *Throttle valve switch II*	Needle swings between 0 and ∞ about 10 times	When accelerator pedal goes back up again, needle should stay in position ∞ **If needle indicates 0, the throttle valve switch must be replaced**
10 Throttle valve Switch III	Resistance ∞ with throttle valve lever in idle speed position	Throttle valve switch incorrectly adjusted or open circuit in wiring *2 prong plug used on older models; 4 prong plug as of Aug '69* **Check adjustment, pull out plug and bridge terminals as shown. If tester still indicates ∞ replace cable harness, and/or replace throttle valve switch** 
11	Resistance 0 Ω with throttle valve opened about 2°	Throttle valve switch incorrectly adjusted or defective. Open circuit in wire **Check adjustment, pull out plug. If tester still shows 0, replace cable harness and/or throttle valve switch**
12 Temperature sensor I (crankcase) *(Intake air Distr.)*	Resistance larger or smaller than the nominal value of 300 Ω	This nominal value is for a temp. of 20° C (68° F). At higher temp. resistance is smaller. If tester does not indicate 0 or ∞ , sensor is serviceable
	Tester indicates ∞ Ω	Open circuit **Bridge plug as shown. When tester reads 0, replace wire harness and/or temperature sensor** 
	Tester indicates 0 Ω	Short circuit **Pull out plug and when tester reading remains same, wire must be defective If reading now is ∞ , the sensor is defective and must be replaced**
13 Temperature sensor II (cylinderhead)	As with step 12 in this case the nominal resistance value is 2500 Ω	

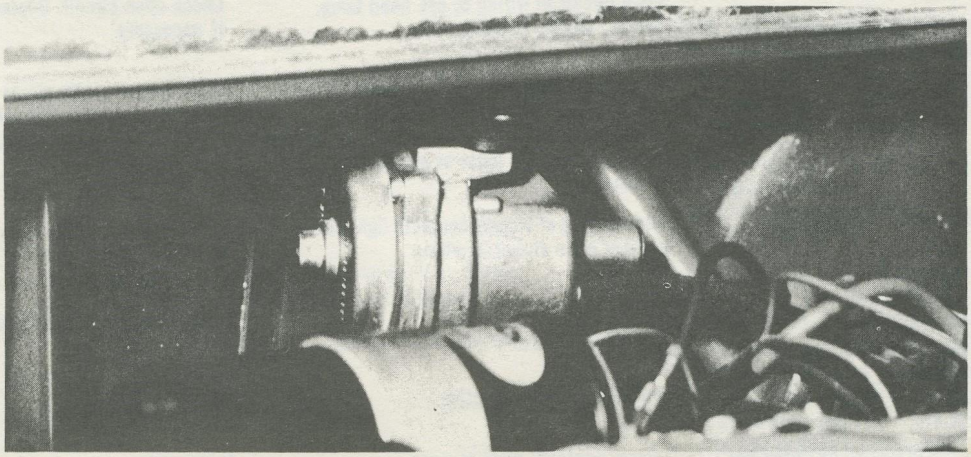
STEP	TESTER READING	PROBABLE FAULT (Remedy given in bold type)
14 Injectors (resistance)	Resistance 0 Ω	Short circuit in wire or at injector **Pull plug out of injector being tested and if tester reads ∞ , replace injector and/or wiring harness**
	Resistance ∞ Ω	Open circuit in wire or injector windings **Bridge the terminal in injector plug and if tester indicates ∞ , wire harness must be defective. If reading is 0, injector is defective**
	Resistance above 3 Ω	Injectors badly grounded **Check ground connections**
15 Fuel pressure in loop line	No fuel pressure	Pump inoperative **Pull off pump plug. Press button marked "Pump" and check voltage at disconnected plug. If reading is 12 Volt, it indicates that pump is defective. Replace. If reading is 0, listen if pump relay operates** **Relay operative: open circuit from terminal 87 of pump relay to pump plug, or from plug to ground. When wiring seems in order, relay must be replaced.** **Relay inoperative: open circuit from main relay terminal 87 to pump relay terminal 86, or from pump relay terminal 85 to wire 19 in wire harness (wire connection in engine compartment). If wires are OK, replace pump relay.**
	Pressure above or below 2 atm (28 psi)	Pressure regulator incorrectly adjusted or defective **Adjust, or if not responsive to adjustment, replace**
16 Fuel pressure in loop line	Pressure drops as soon as button marked "Pump" is released	Leak in fuel line system between fuel pump and pressure regulator **Clamp the fuel ring line shut in front of the left side injectors. Release "Pump" button and if no pressure drop is indicated, the leak is in the pressure line or pump. If pressure does drop, there must be a leak at the injectors or pressure regulator. To check, remove both injector pairs separately and check visually. If there is no evidence of a leak, replace pressure regulator**
16a. CHECKING COLD START VALVE AND TEMP. SWITCH	1. pressure decreases when operating starter	temp. switch defective **Replace**
	2. Pressure does not decrease when operating starter	*Check wire 31 from starting jet to starter terminal 50. If open circuit, replace wiring. Check electromagnetic valve (coil resistance 4.2 Ω at 20°C-68°F)* *If pressure does not decrease, replace thermo switch, or check cold start valve as outlined above*
17 Distributor (trigger) contacts I and II	Voltage difference more than 2 graduations on V scale	Distributor contacts out of adjustment **Replace complete contact holder**
18 Switch A in pos. "Pressure Switch" (only for older cars up to Aug. '69)	0 shown on scale	Pressure switch inoperative, or open circuit in wiring **Disconnect wire, bridge as shown. If tester indicates 0 Volt, replace cable harness and/or pressure switch**

TROUBLE SHOOTING CHART FOR THE FUEL INJECTION SYSTEM ONLY

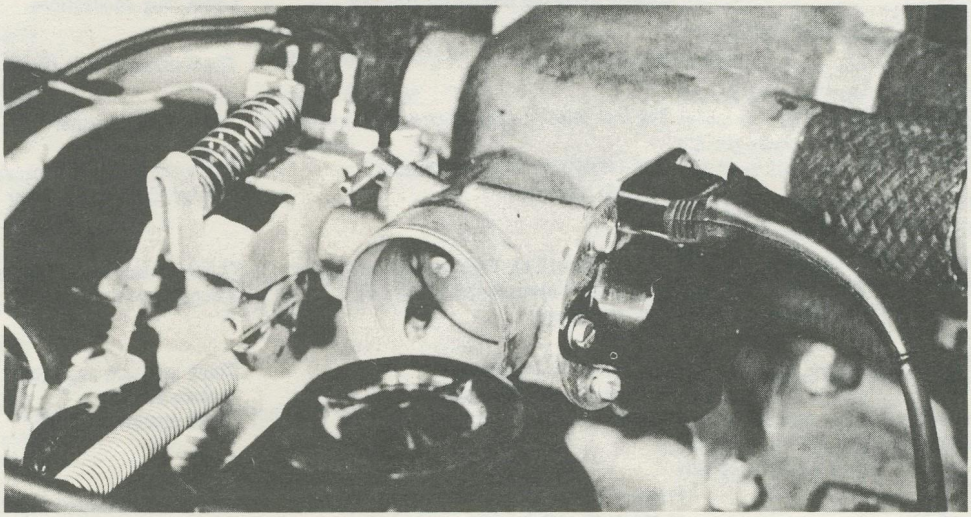
DEFECT	CAUSE	REMEDY
Engine cannot be started: electric fuel pump inoperative	Wires to pump or pump relay defective	Switch ignition on and off and listen for relay operating sounds, or test with voltmeter
	Pump relay receives no voltage at terminal 86 (12 volts) due to defective main relay. Open circuit in wiring	Check with voltmeter
	Pump relay has 12 volt at terminal 86, but no ground at 85	**Note:** remember that it takes a delay of 1 to 1.5 seconds for the relay to start operating after ignition is switched on. Make check with voltmeter. Relay is wired to ground via control unit
	Fuse to pump relay terminal 30/51 defective	Replace fuse 8 A
	Open circuit in wire from pump relay 87 to pump plug	Fix open circuit. Check plug connections
Engine cannot be started: electric fuel pump operative	Electric plug at pressure sensor disconnected, or open circuit causing excessively rich mixture (flooding)	Replace plug or repair wiring **Note:** restarting engine may be difficult due to flooding. Temporarily disconnect injector plug while cranking engine
	Open circuit in wiring to cyl. head temp. sensor. Engine flooded	Check open circuit. Replace sensor if necessary
	No pressure build-up in fuel loop line which may be caused by a pinched line or defective pressure regulator. Plug connection to trigger contacts loose or open circuit in wiring	Check pressure with gauge (which should be 2 atm-28 psi-) when operating starter motor. If necessary replace pressure regulator
Engine starts when cold but stalls again	Electric plug at trigger contacts (ign. distr.) loose or open circuit in wiring	Connect tester if necessary to trace trouble and go through steps 8 and 9. If necessary, replace wiring harness and/or trigger contacts
	Trigger contacts defective Also refer to "Engine cannot be started"	Replace complete trigger contact holder
	Pressure sensor defective	Replace
Engine quits (usually preceded by misfiring)	Trigger contacts dirty or worn	Check with tester going through steps 8 and 9. If necessary replace contact holder
	Electric plugs not pushed on securely	Check plug connections
	No fuel pressure	Check pressure with gauge
Engine does not fire on all cylinders. One cylinder misfires consistently. Exhaust shows white smoke	One fuel injector sticking	Replace fuel injector
	Plug connection loose or injector windings defective	Check connections. If necessary replace injector. Check with tester
Engine misfires (which is not caused by defects in the ignition system)	Loose connections. Poor ground connections at injectors (injectors fail in pairs with poor grounding)	Check connections. If necessary tighten ground screws
Engine does not attain full power output	Insufficient fuel pressure Pressure sensor defective Throttle valve does not open fully	Check pressure regulator Replace sensor Check operation
	Pressure switch not working or open circuit in pressure switch wiring (older cars)	Check pressure switch with tester

TROUBLE SHOOTING CHART FOR THE FUEL INJECTION SYSTEM ONLY

DEFECT	CAUSE	REMEDY
Excessive fuel consumption	Sensors not operating, or high voltage drops in wiring system	Check hose connections. With tester go through steps 1 through 13
	Throttle valve switch III incorrectly adjusted	Check and adjust with tester
	Excessive fuel pressure	Check pressure regulator and replace if necessary
Engine hunts excessively in the lower rpm range (1000-2000 rpm)	Hose between auxiliary air regulator and intake air distributor disconnected	Reconnect hose
	Throttle valve stop incorrectly adjusted (throttle valve stays open too wide)	Make necessary adjustment
	Engine speed too high	Make correct idle adjustment.
Engine backfires when accelerating	Mixture enrichment in throttle valve switch does not function	Check operation of switch with tester
Excessively high idle speed which cannot be adjusted	1. Leakage in idle air system 2. Rubber seals of injectors leaking 3. Throttle valve incorrectly adjusted	1. Check system 2. Replace seals 3. Make necessary adjustment



The pressure sensor is fitted on the left side of the engine compartment. Early models had a slightly different mounting



The throttle valve switch is fitted next to the air intake of the air intake housing

REMOVING AND INSTALLING THE VARIOUS COMPONENTS

When disconnecting cable plugs, pull at the plug, never at the cable itself.

Pressure sensor

The pressure sensor is mounted on the left side of the engine compartment. To remove, pull out the plug (do not pull at the cable), loosen, but do not remove the front mounting screws. Unscrew the rear mounting screw. Pull the sensor unit to the rear and remove. Disconnect the vacuum hose.

On the latest models the sensor is mounted slightly different as shown, but removal procedure is similar.

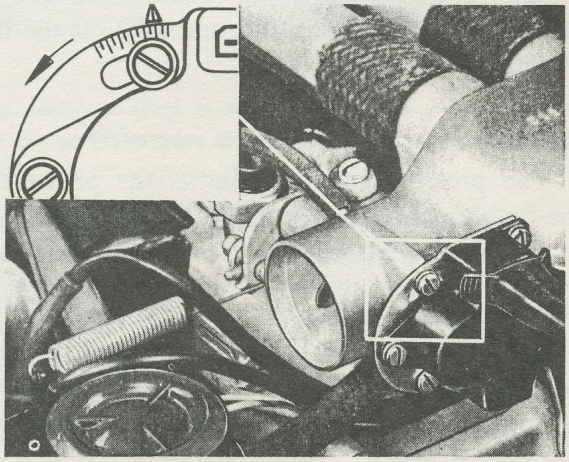
Installation

Installation is in the reverse sequence. In order to prevent the vacuum unit from getting dirty it is advisable to remove the protective sleeve on the hose connection only just before pushing it on. The pressure sensor must be installed in a horizontal position.

THROTTLE VALVE SWITCH

Removal

The throttle valve switch is mounted on a graduated base plate which itself is fitted to the air intake housing as shown. To remove the unit it is convenient to remove the air cleaner first. Pull out plug, remove both mounting screws and take off unit.



The throttle valve switch can be removed after the 2 retaining screws have been loosened

Installation

The switch must be installed with the plug connection facing up.

Adjusting of switch

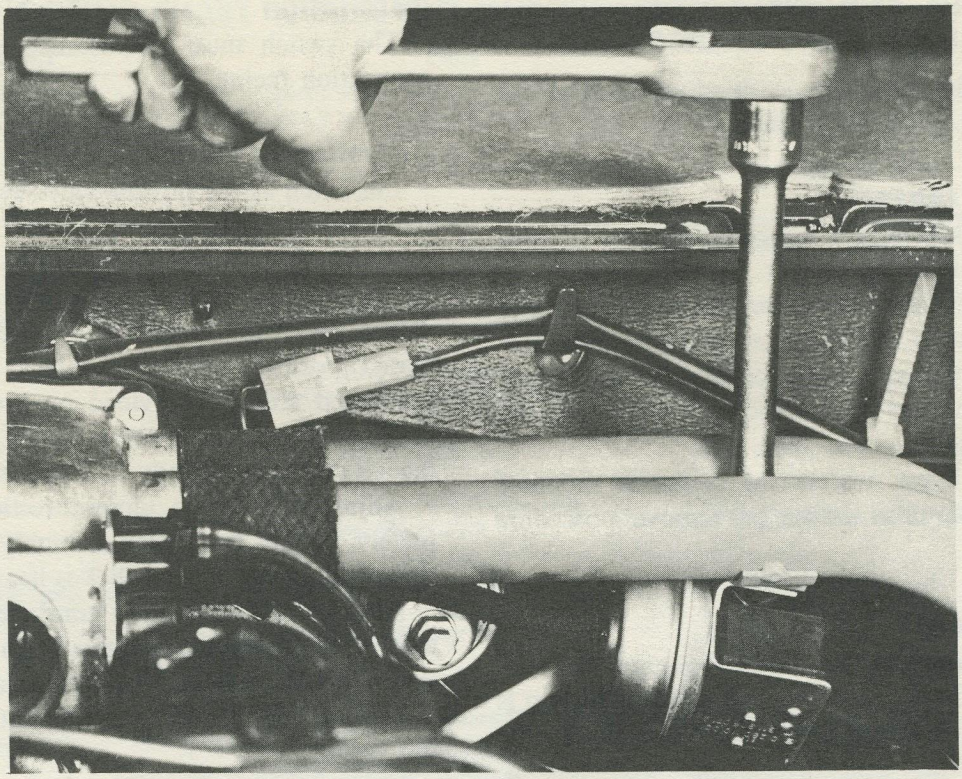
Inasmuch as the throttle valve switch regulates the complete fuel shut off in the specified rpm range, its adjustment is important.

The throttle valve switch must come into operation when the throttle has moved 2° from its closed position. For convenient adjustment a graduated scale is provided on the switch base plate. One graduation mark equals 2°. The scale faces a mark on the body of the air intake housing.

Adjust as follows: close throttle valve completely. Rotate the switch assembly in the direction of the arrow until a click is heard.

Note the position, then continue rotating the unit in the same direction one further graduation space (2°). Tighten the base plate mounting screws in this position (adjustment tolerance of the switch is 1°-3°).

Unhook return spring and check if throttle valve moves easily.



The pressure switch can be removed with a 10 mm socket as shown. Use a slender socket in order to get between the intake manifolds. The pressure regulator can be seen to the left of the pressure switch

PRESSURE SWITCH

Removal

The pressure switch is mounted between the two right side intake manifolds. The mounting screw is removed with a 10 mm socket wrench as shown. Remove the switch and pull off the vacuum hose and the electric plug.

Installation

When installing the switch, the plug must be inserted first. Mount the switch and push on the vacuum hose. When tightening the nut, check that the unit remains clear of the manifolds. If necessary install a spacer washer.

PRESSURE REGULATOR

The pressure regulator is fitted to the front engine cover plate underneath the intake manifold a little to the left of the pressure switch. The mounting nut is in front of the cover plate.

Removal

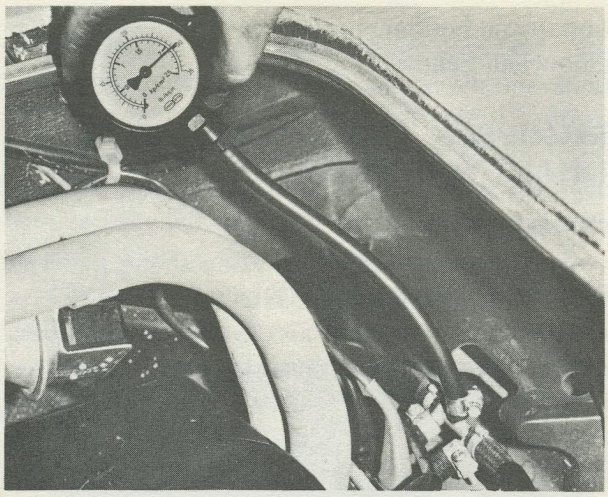
It is best to remove the aircleaner. Unscrew the right side mounting screw of the front mounting plate so that it can be pulled back a little for easier access to the 17 mm retaining nut.

Detach the fuel hose. Clamp it off or lift it up high enough to prevent fuel spillage.

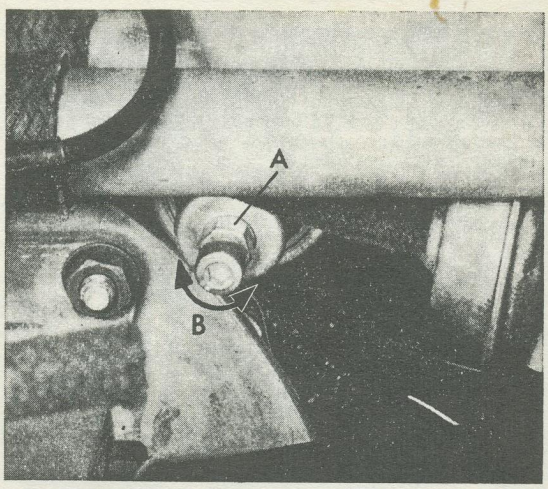
With a 17 mm bent box wrench unscrew the nut. Remove regulator unit and take off the hose leading to the injectors.

Adjustment of pressure regulator

The pressure regulator limits the pressure in the fuel loop line to 2 atm (28 psi) and inasmuch as pressure variations have a marked influence on the fuel mixture, correct adjustment is important. The fuel pressure in the loop line is checked with a pressure gauge as shown. Start engine and run it at idle speed. If pressure in the line is not correct, loosen lock nut A and adjust fuel pressure with nut B. After correct adjustment is obtained, retighten lock nut.

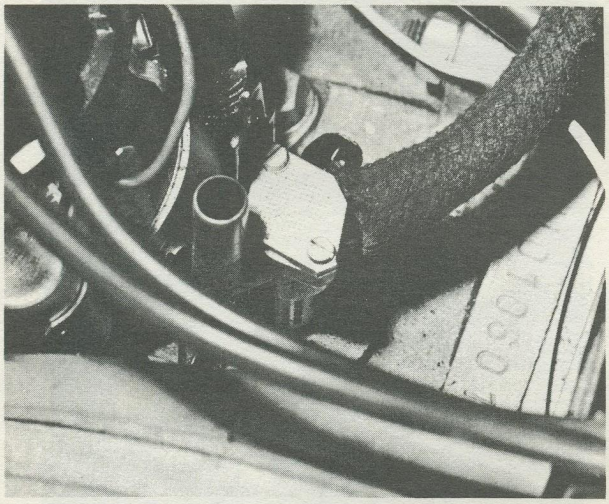


Checking fuel line pressure with pressure gauge

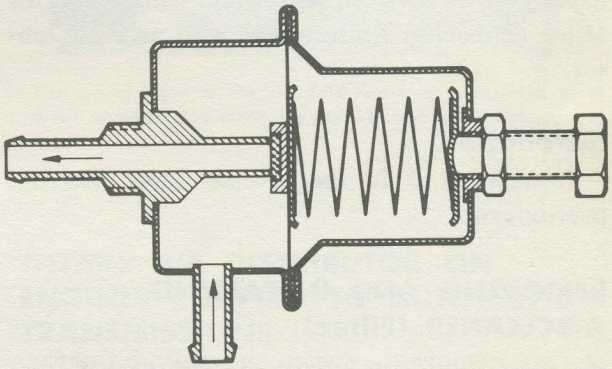


Adjusting pressure on pressure regulator

A. lock nut
B. adjusting nut



Temp. sensor 1 is fitted on top of the crankcase. Be sure nothing falls into crankcase when sensor is removed



Section of pressure regulator. The pressure regulator limits the fuel pressure to 2 atm (28 psi). Adjustment nut and lock are shown at right

CRANKCASE TEMPERATURE SENSOR

Removal

To remove crankcase temperature sensor, first pull out electrical plug. Unscrew the 13 mm retaining nuts. Cover hole to prevent anything falling into crankcase.

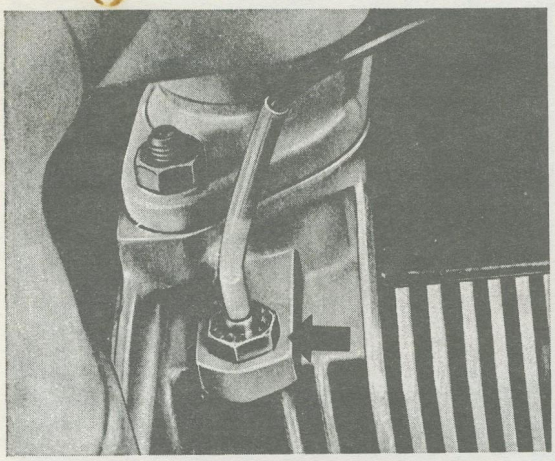
Installing

Installation is in the reverse sequence. Tighten retaining nuts to 1.5 mkg (11 lb-ft).

AUXILIARY AIR REGULATOR

Removal

To remove air regulator, temperature sensor must be removed first as described above. Unscrew the second mounting nut on the regulator and remove regulator. Cover hole in crankcase.



The cyl. head temp. sensor is fitted to the left side cylinderhead. When installing, do not overtighten. Use 13 mm open end wrench

CYLINDERHEAD TEMPERATURE SENSOR

Removal

The cylinderhead temperature sensor is fitted to the left cylinderhead as seen from the rear. Separate wire between sensor and wire connector at the connector. Raise vehicle and unscrew sensor.

Installation

Installation is in the reverse order. Do not overtighten.

REMOVING AND INSTALLING AIRCLEANER (Filter)

Removal

To remove aircleaner, proceed as follows: pull off hose for the crankcase ventilation and the auxiliary air valve. Remove clamp of rubber bellows at aircleaner, and pull bellows back.

Loosen clamp at the rubber elbow at intake air distributor. Loosen and remove wing nut on top of aircleaner. Remove aircleaner.

Cleaning filter

To clean filter (aircleaner), release the three clips and take off the top part. Clean filter assembly. Refill with oil (SAE 30 is recommended) up to the red mark.

Installation

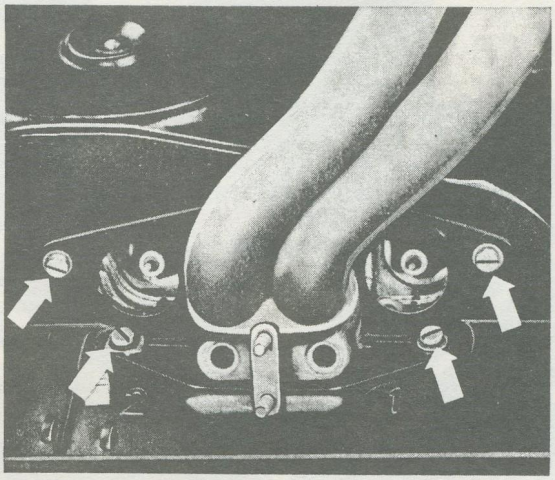
When reassembling, be sure that the red arrows on top and bottom part line up. Reconnect rubber elbow and bellows.

REMOVING AND INSTALLING INTAKE MANIFOLDS

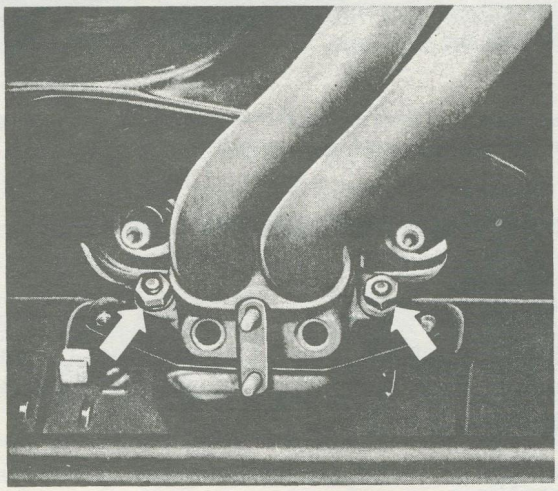
Removal

The accompanying illustration shows the right side intake manifold. To remove manifold, proceed as follows: remove air cleaner. Remove pressure switch. Remove the injectors together but do not detach them from the fuel line. Remove the four screws indicated by the arrows in the illustration.

Remove the two retaining nuts indicated by the arrows in the illustration together with the washers. Take off right side manifold. Removal procedure for the left manifold is identical.



The four screws indicated by the arrows must be removed

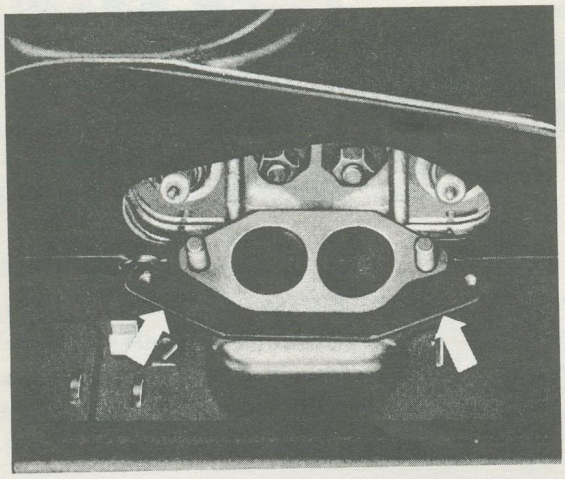


The arrows indicate the two intake manifold flange retaining screws

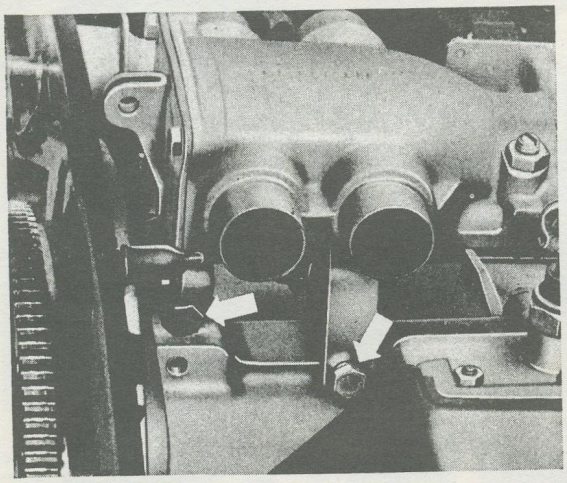
Installation

Installation is in the reverse sequence. The cover plate indicated by the arrows should be put in place first, but do not as yet screw it down. When the cover plate is finally fastened remember that the plug connection for grounding the injectors is fastened together with the rear mounting screws. Always use new gaskets.

The injectors are installed as has been described before.



When reinstalling, install cover plate (arrow) first. The plug connection for grounding the injectors is fastened together with the rear mounting screw



Removing air intake distributor. The arrows point to the retaining nuts

INTAKE AIR DISTRIBUTOR

Removal

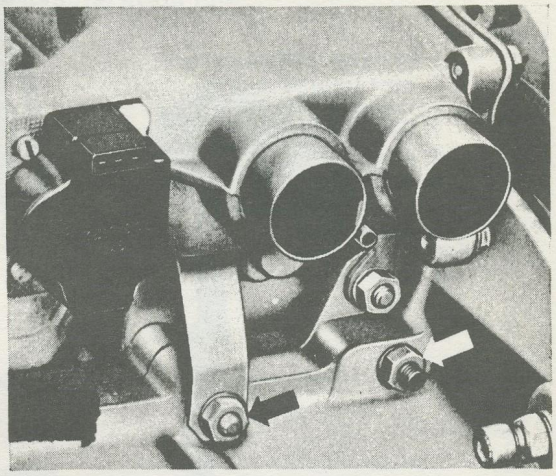
The intake air distributor is removed as follows: remove aircleaner. Remove pressure switch. Remove left and right intake manifolds.

Remove throttle valve switch. Remove throttle valve cable.

Pull off vacuum hose between intake air distributor and ignition distributor and the hose between air distributor and pressure sensor. Also pull off hose between auxiliary air regulator and intake air distributor.

Installation

Installation is in the reverse sequence. The crankcase nut (indicated by black arrow) must be tightened to 3.4-3.6 mkg (24-26 lb-ft).



The arrows point to the manifold retaining screws. The black arrow indicates the crankcase nut which must be tightened to 3.4-3.6 mkg (24-26 lb-ft)

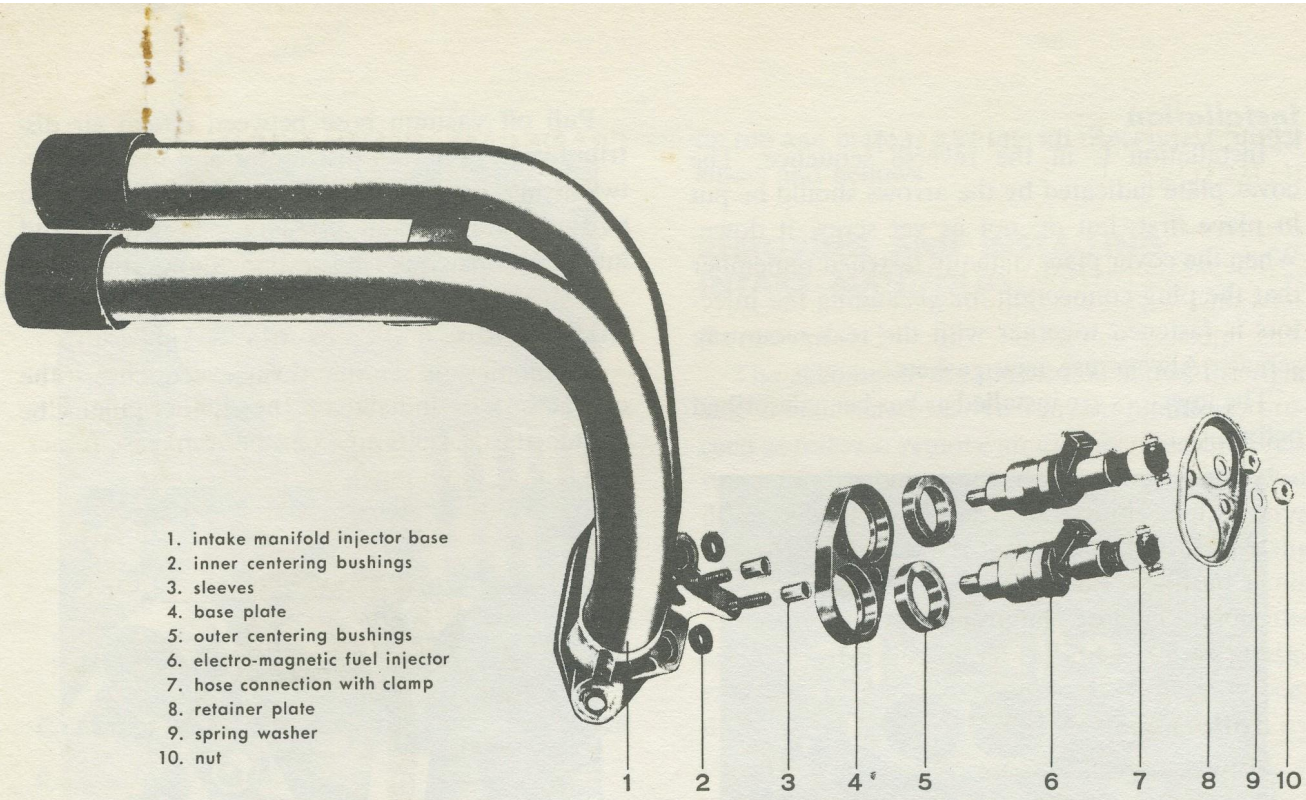
INTAKE AIR DISTRIBUTOR ON ENGINES COUPLED TO AUTOMATIC TRANSMISSIONS

The intake air distributor used on engines fitted to automatic transmissions is slightly different. A description of this type is given on page 43.

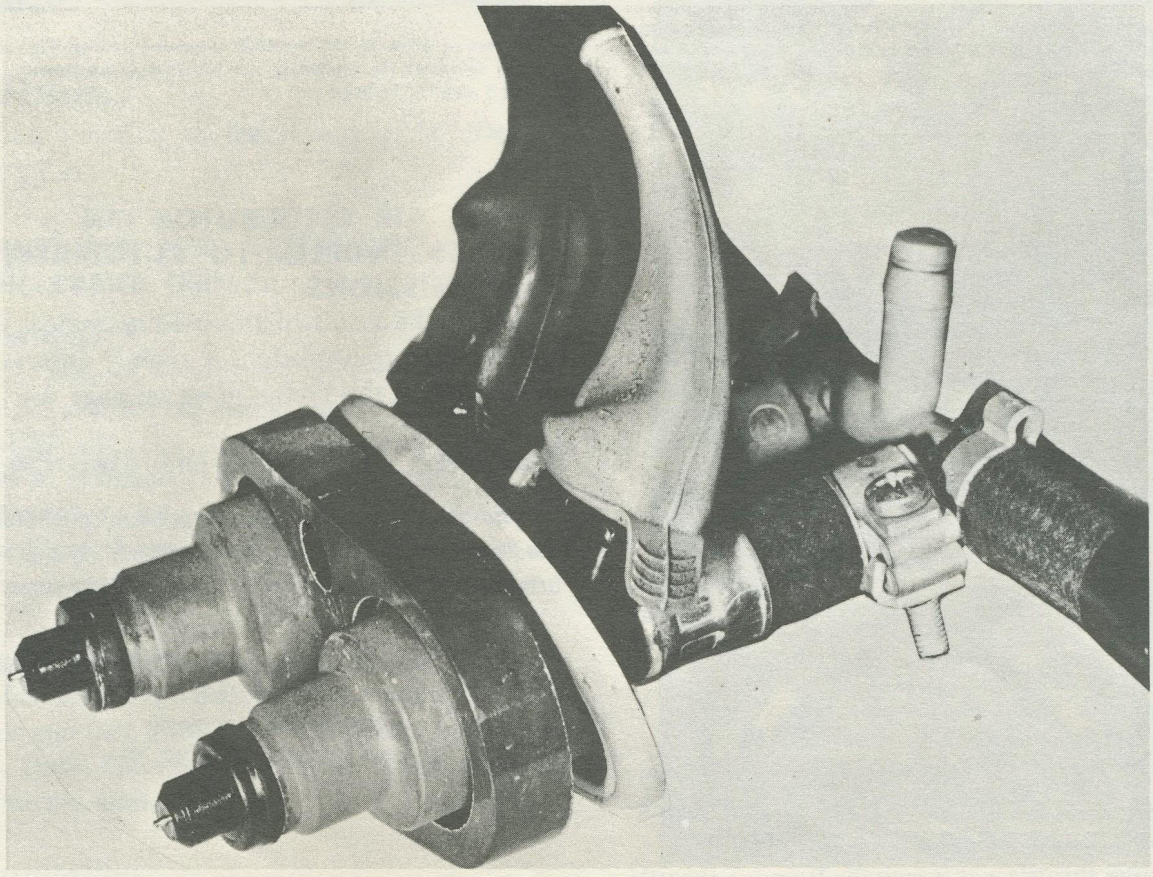
MODIFIED AIR INTAKE DISTRIBUTOR

The air intake distributor has been modified for the latest models. The part numbers of the types used are as follows:

311 133 055l L on manual shift cars up to Aug. '69 (fitted with cold start jet)
311 133 055 D on autom. transm. cars up to Aug. '69 (fitted with cold start jet)
311 133 055 E on manual shift cars as of Aug. '69
311 133 055 F on autom. transm. cars as of Aug. '69



Exploded view of the fuel injector assembly



One pair of injectors removed from the intake manifold. The T-piece with stop screw can be seen on the right

REMOVING AND INSTALLING INJECTORS

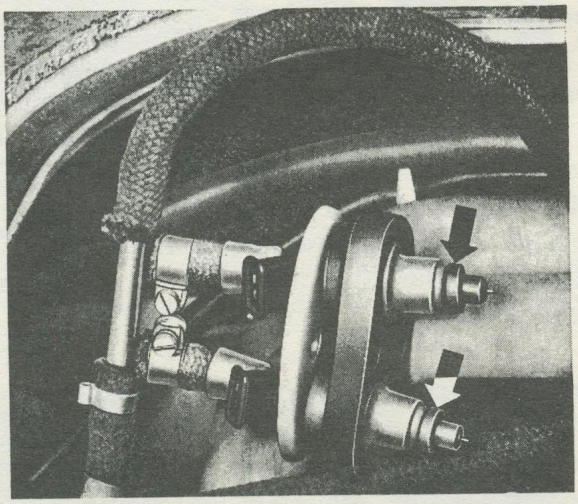
Removal

The accompanying illustration shows the interrelationship of the various injector assembly parts. The injectors on one side should be removed together. If the injectors are to be checked for leaks, do not separate them from the fuel line. Pull out the cable plugs. Unscrew the two retainer plate nuts (use 10 mm socket). Remove both injectors with bushings, sleeves, base plate, retainer plate as shown in the illustration. Be sure that the inner bushings 2 are removed from their seats.

Loosen the hose clamps and pull out injectors, taking care not to damage the needles.

Installation

Installation is in the reverse sequence. The exploded view shows the correct interrelationship of the various parts. Spring washers should be used with the retaining nuts. Tighten to .6 mkg (4.5 lb-ft).

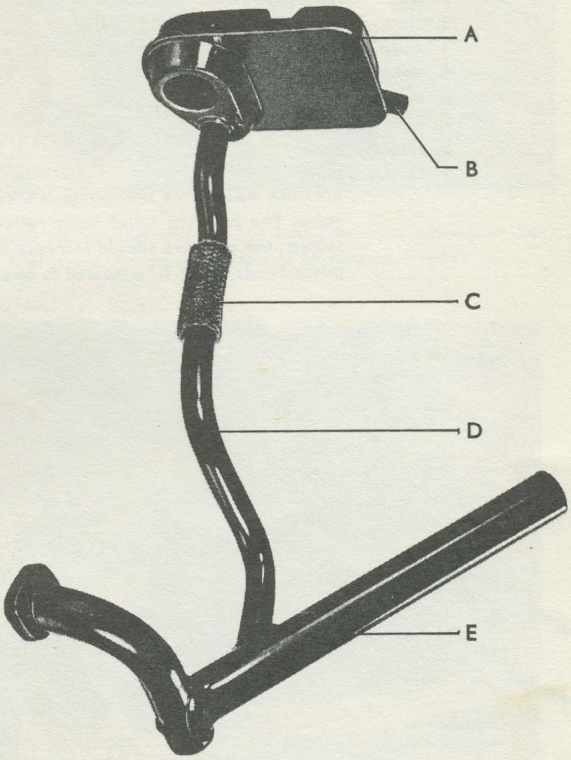


The two arrows point to the bushings which must be fitted to the injector units

CRANKCASE VENTILATION

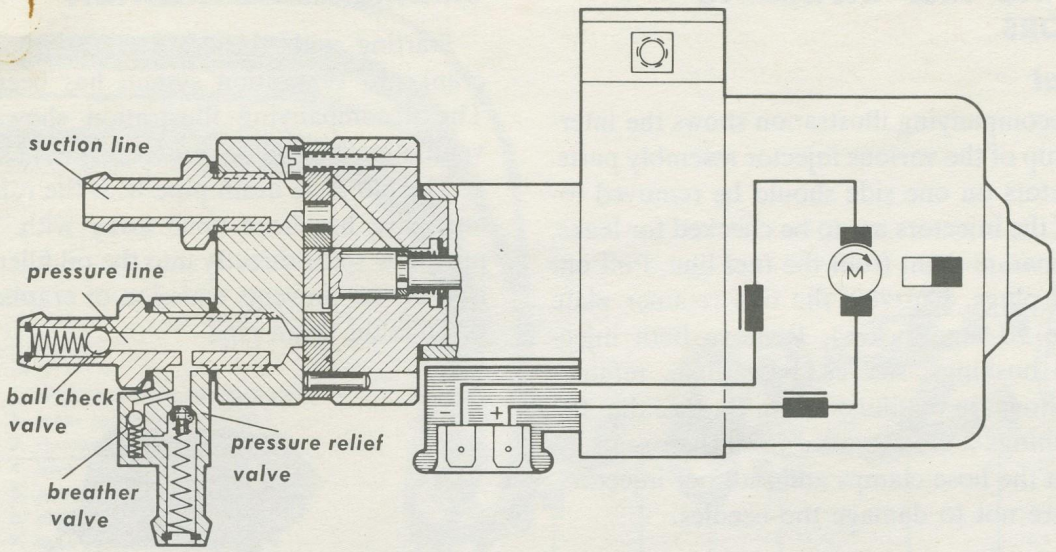
Starting with the 1968 1600 models a new crankcase ventilation system has been adopted. The accompanying illustration shows the new ventilation and oil filler assembly.

The old style drain pipe with the rubber draining valve has been done away with. The drain pipe now spills directly into the oil filler pipe. The new device prevents emission of crankcase fumes through the drain pipe.

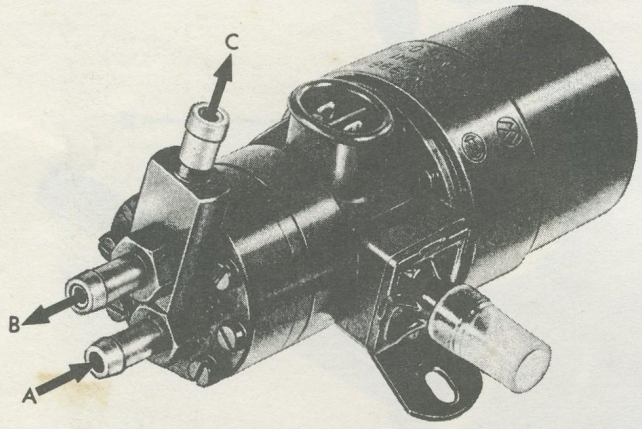


Crankcase ventilation system for latest engines

A. vent box
B. hose connection to aircleaner
C. Connecting hose
D. connecting tube to oil filler pipe
E. oil filler pipe



Diagrammatic view of the electrically operated roller-type rotary fuel pump. In the pressure side of the fuel pump is a check valve, a breather valve and a pressure relief valve. The pressure relief valve relieves the pressure if due to a fault in the pressure system, the pressure should increase considerably above the nominal value. The electric pump needs about 2.1 amperes to operate



The electric fuel pump is fitted to the front of the chassis. A diagrammatic view is also shown
A. suction line B. pressure line to frame C. overflow line

REMOVING AND INSTALLING FUEL PUMP

Removal

The fuel pump is situated at the front end of the chassis and is fastened to two rubber-bonded supports. It has three fuel lines: a suction line A, a pressure line B and an overflow line C (see illustration).

To remove pump, proceed as follows: use special pinch clamps as shown on the fuel hoses to prevent spillage. Pull off cable plug.

Cut the hose clamps, pull off hoses and catch outflowing fuel. Lift the pressure hose (the one that goes to the frame) to prevent draining of the fuel loop line.

Unscrew the pump retaining nuts and remove pump.

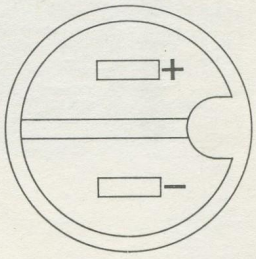
Installation

When installing, observe the following: fit hoses to pump. The pressure line must be fitted with a hose clamp. Mount pump to its supports. Remove the special hose clamps. Insert the cable plug and be sure that the protective cap is correctly installed.

The cable plug housing on pump body

The two prongs of the plug are held in the housing by a projection. If the prongs are to be removed push the projection back and pull plug out toward the rear.

When installing, remember that the negative ground wire (brown) is to be installed in the bottom as shown with the half circular cavity toward the right.



The negative ground wire (brown) must be installed in the bottom when the plug receptacle is viewed as shown

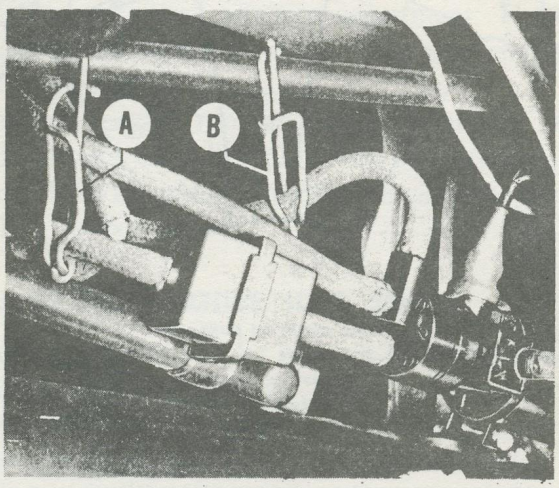
FUEL FILTER

A filter is placed in the fuel line between the fuel tank and the pump. The filter is placed close to the pump as shown and it should be exchanged every 10,000 km (6000 miles).

Replacing filter

To replace filter, proceed as follows: use a pinch clamp as shown (or similar device) to clamp the hose shut at position A (between filter and tank).

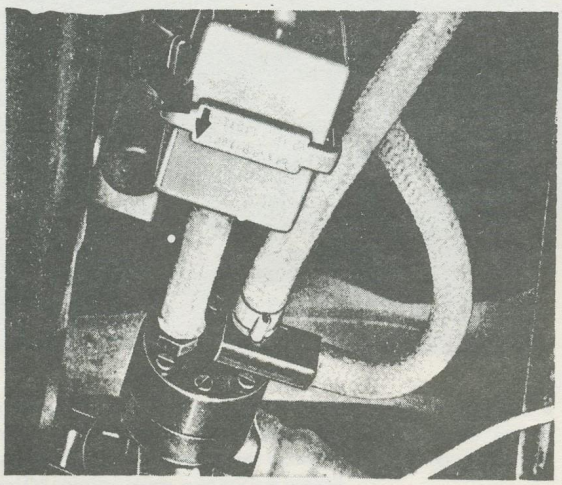
Use a similar clamp at B (between the T-piece and the pump pressure relief valve).



The fuel filter is placed in the fuel line as shown. Special pinch clamps are in place at A and B

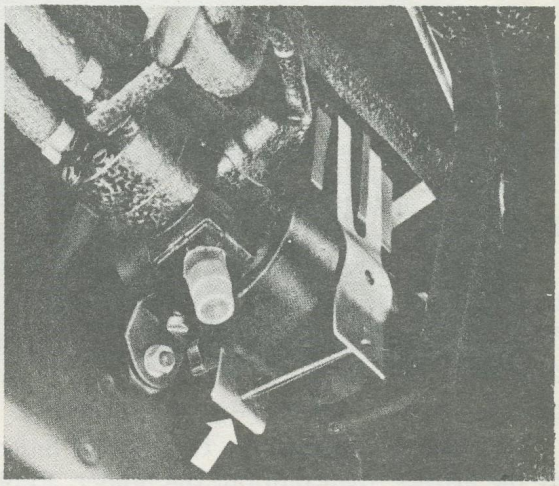
Installing

When fitting a new filter, make sure that the arrow (indicating direction of flow through the filter) faces the pump.

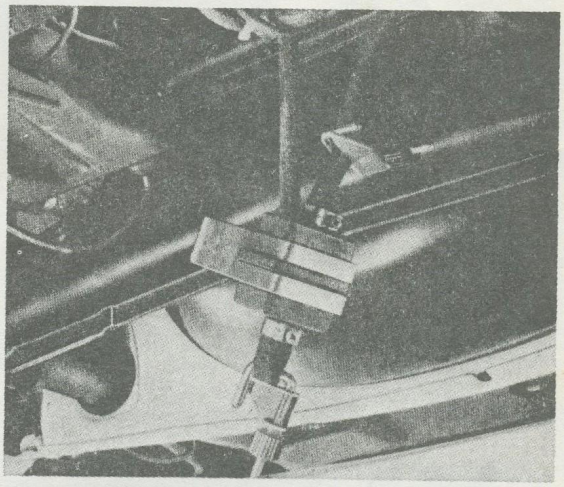


When installing filter, be sure that the arrow points to the pump as shown

On later models the fuel filter has been placed on top of the fuel pump with a bracket. To remove filter, first remove the retaining pin (arrow).



Around the middle of 1968 the fuel filter was placed on top of the fuel pump. Arrow points to pin of support bracket



Fuel hoses should be clamped off close to the filter element. The clamps shown are very effective and easily made in the workshop

IGNITION DISTRIBUTOR

Removal

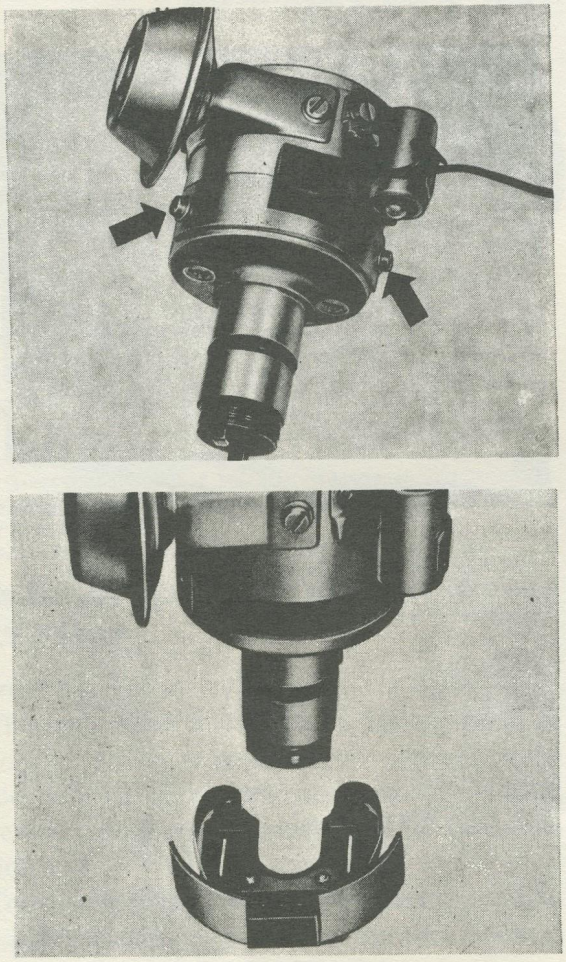
Distributor removal procedure is generally similar to that of the carburetor engines, but note the following: it is recommended to first remove the distributor cap.

Pull out the three prong plug, then detach wire from terminal 1 on the coil. Loosen bracket clamp screw and extract distributor unit.

Replacing trigger contacts

The trigger contacts are mounted on a separate breaker plate in the base of the distributor unit. These contacts cannot be adjusted. If worn or defective, the complete assembly must be replaced.

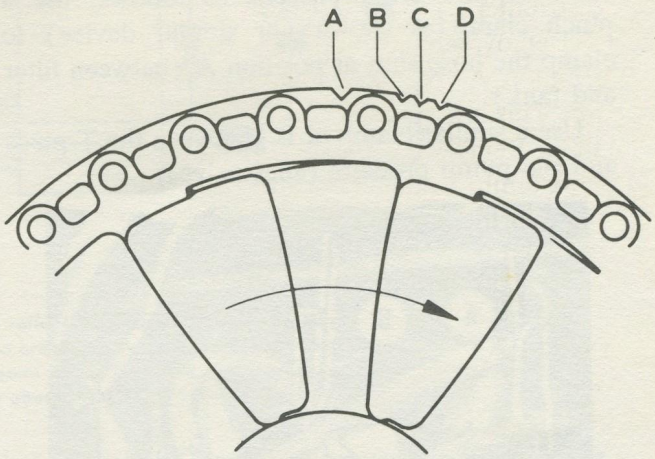
To remove, unscrew the two screws indicated by the arrows, then pull out the holder. Replacement is in the reverse sequence.



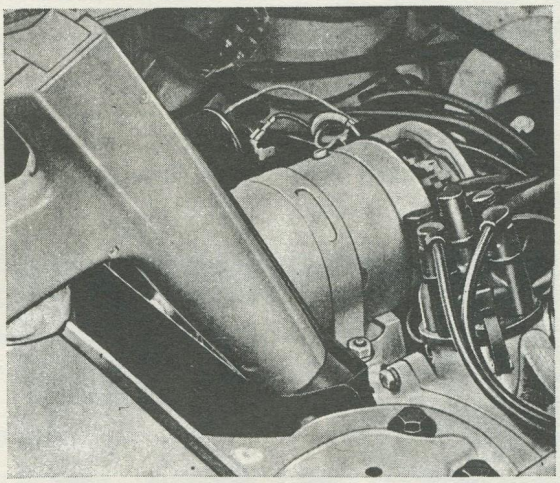
To replace trigger contacts, remove the 2 screws indicated by the arrows and pull out breaker plate

ADJUSTING SPARK ADVANCE

On the fuel injection engine static spark advance is set at top center. The accompanying illustration shows the markings on the pulley rim. A stroboscopic timing light must be used and alignment tool VW 660 is convenient to line up the timing marks. Be sure engine is fully warmed up.



Timing marks on pulley rim
A. top center
B. 7.5° before top center
C. 10° before top center
D. 12.5° before top center



Checking spark timing with stroboscopic timing light

Proceed as follows: adjust breaker points to .4 mm (.016 in.) or adjust dwell angle to 47°-53°. Connect stroboscopic timing light to No. 1 cylinder.

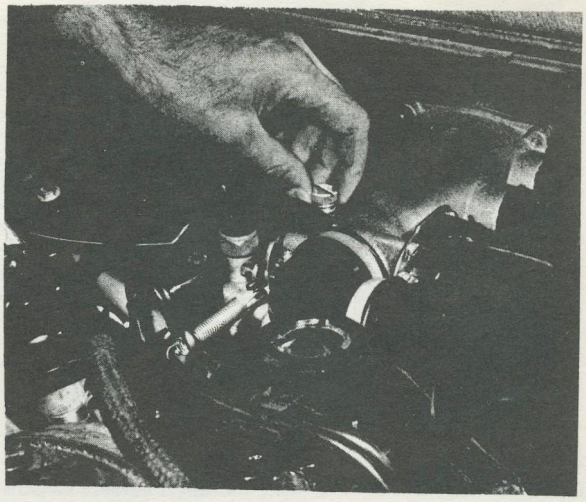
Loosen ignition distributor clamp screw until distributor can just be rotated by hand. Pull vacuum hose off vacuum unit. Remove rubber stop on pulley housing.

Start engine and let it run at idle speed. Aim timing light at pulley and rotate distributor body until mark A lines up with tool VW 660.

After correct adjustment is obtained, retighten distributor body clamp screw.

Reconnect vacuum hose to distributor vacuum unit. Recheck spark advance adjustment. There should be no spark advance when the engine runs at idle speed.

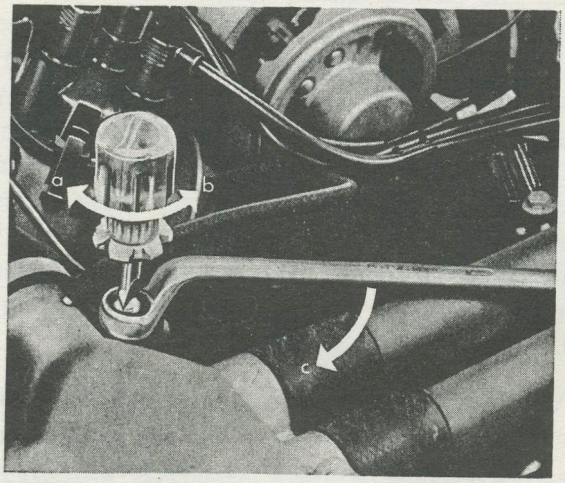
Increase engine rpm and observe amount of spark advance on pulley rim. With increased rpm the notch on the pulley rim must move to the left. Replace rubber stop.



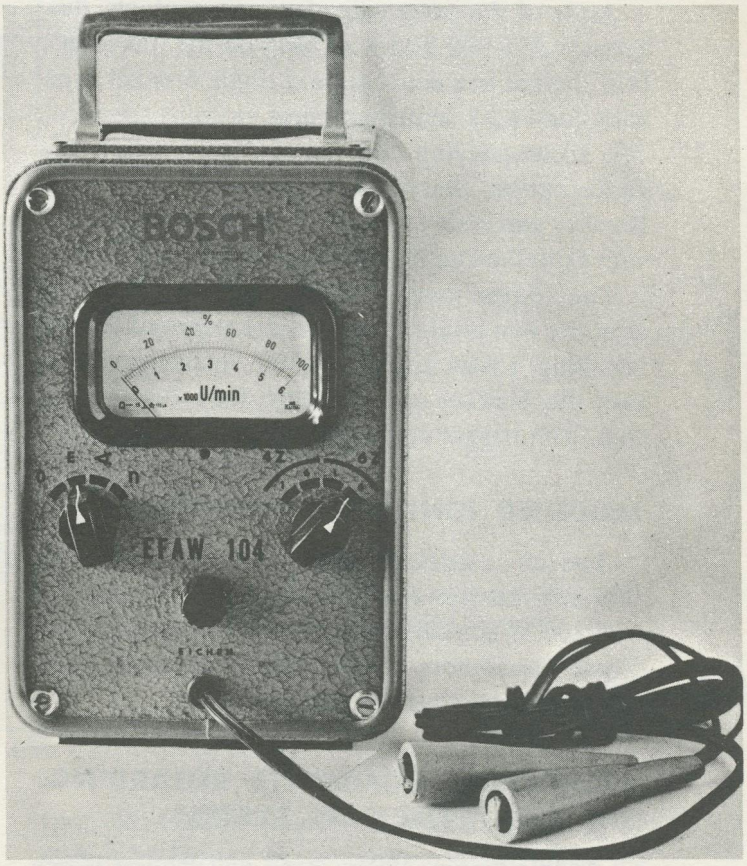
Adjusting idle speed by turning knurled screw

ADJUSTING ENGINE IDLE SPEED

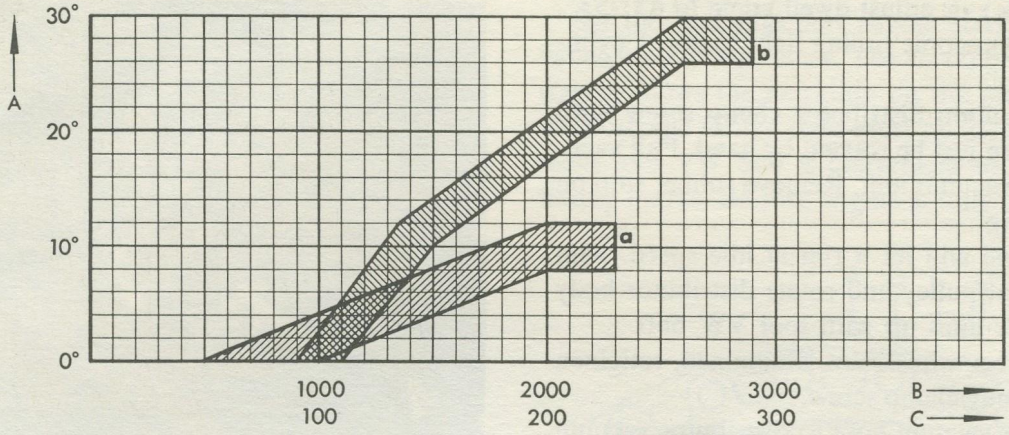
Start up engine and let it attain operating temperature. Use an accurate electric tachometer. Loosen lock nut (15 mm) on idle adjusting screw, adjust idle speed rpm to 850 (+50), then retighten lock nut. Make sure throttle valve is completely closed.



Adjusting idle speed. Turning the adjusting screw in direction a increases rpm. Direction b decreases engine rpm. After correct adjustment has been obtained tighten lock nut (c). On older models a knurled screw with spring is used



Bosch tester EFAW 104 is an elaborate and accurate instrument for checking engine rpm and ignition breaker point dwell angle. This tester can be used for most types of engines



Spark advance diagram of 311 905 205L distributor
A. advance in crankshaft degrees
B. crankshaft rpm
C. vacuum in mm Hg
a. spark advance (vacuum)
b. spark advance (centrifugal)

Ignition distributor Bosch 311 905 205 L

Aside of the extra pair of trigger contacts, distributor 311 905 205 L as used on the fuel injection engines is a conventional single breaker type with combined centrifugal and vacuum advance. The accompanying diagram shows the spark advance curves. Static spark advance is set to 0°. Breaker gap is set to .4 mm (.016 in.). If adjusted with a dwell meter it should be adjusted to 47°-53°.

The trigger contact holder can be taken out after the two retaining screws are removed. When installing a new contact holder, sparingly lubricate the breaker levers where they rub on the cam. The trigger contacts cannot be adjusted.

MODIFIED IGNITION DISTRIBUTORS

The later models are fitted with distributors 311 905 205 AB (for cars with manual shift) and 311 905 205 M (on cars with automatic transmission). These distributors have a slightly different spark advance curve than the one shown.

ADDITIONAL COMMENTS REGARDING THE FUEL INJECTION SYSTEM

At this writing Volkswagen and Robert Bosch have had about four years production experience with the electronic fuel injection system. In general it has proved to be efficient and durable.

The overall characteristics of the injection engine are somewhat different from its carbureted counterpart.

It is essential to remember that the system has been designed and set up to deliver as lean a mixture as is practicable without causing excessively high engine operating temperatures which could cause burned valves and pistons.

Another characteristic of this system is that the absolute manifold pressure and engine speed (rpm) are used as the main determining parameters. The throttle valve position is not used as a factor (as it is for the Porsche engine which is fitted with the Bosch *mechanical* injection system). This circumstance under certain conditions may cause a very slight delay in engine response when the throttle is suddenly opened from a low rpm range. This delay however is very slight (it is caused by the inertia of the slow moving air mass in the manifolds which have to adjust to the wider throttle openings), and is in the order of about .05 seconds.

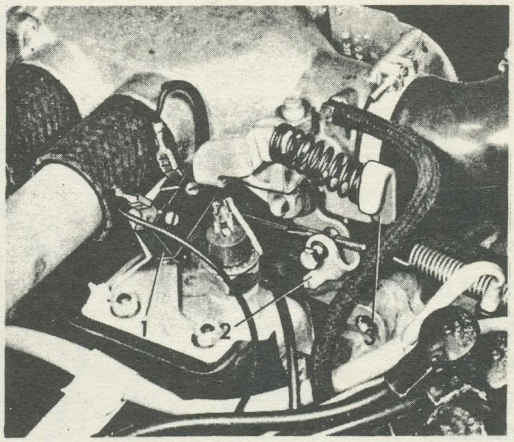
Very noticeable is the extreme smoothness of engine operation and there are no flat spots when the accelerator is floored. Also, the fuel supply is terminated as soon as the ignition is switched off and running on of a hot engine is prevented.

The absence of bulky carburetors make for an uncluttered engine compartment and spark plug change has been made very much easier.

INTAKE AIR DISTRIBUTOR ON ENGINES COUPLED TO AUTOMATIC TRANSMISSIONS

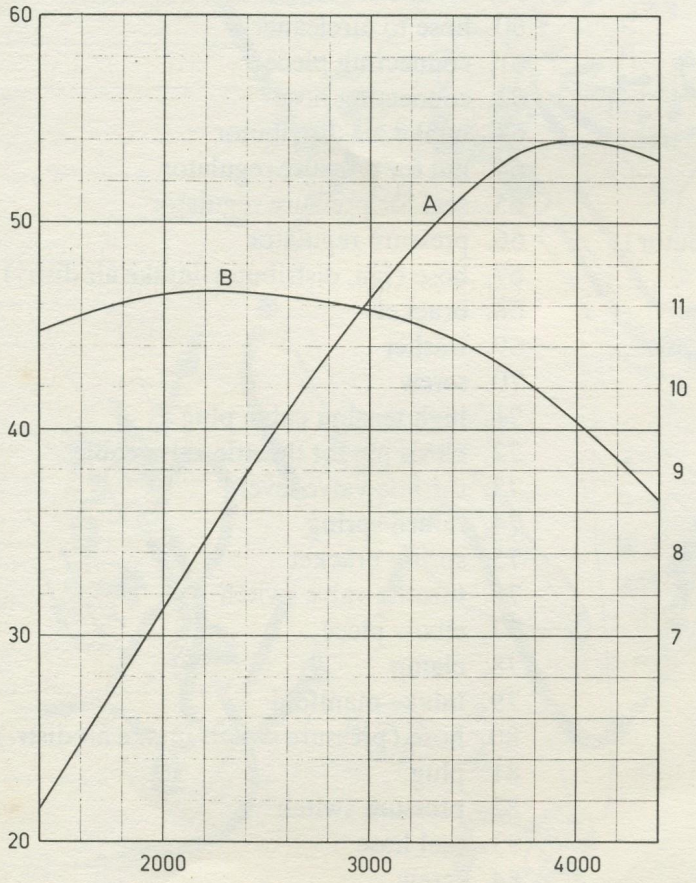
The combination of an automatic transmission and engines with fuel injection was first used for the 1969 models. These engines are fitted with a slightly different type intake air distributor.

This type intake air distributor differs from the one used on engines with conventional transmissions as follows: there is provision for the connection of a vacuum line to the automatic transmission, and the operating lever for the throttle valve has been changed to enable it to actuate the kickdown switch for the automatic transmission. The accompanying illustration shows this detail.



Fuel injection engines coupled to an automatic transmission are fitted with a different air intake distributor and different throttle valve lever

1. kickdown switch
2. actuating lever for kickdown switch
3. throttle valve lever

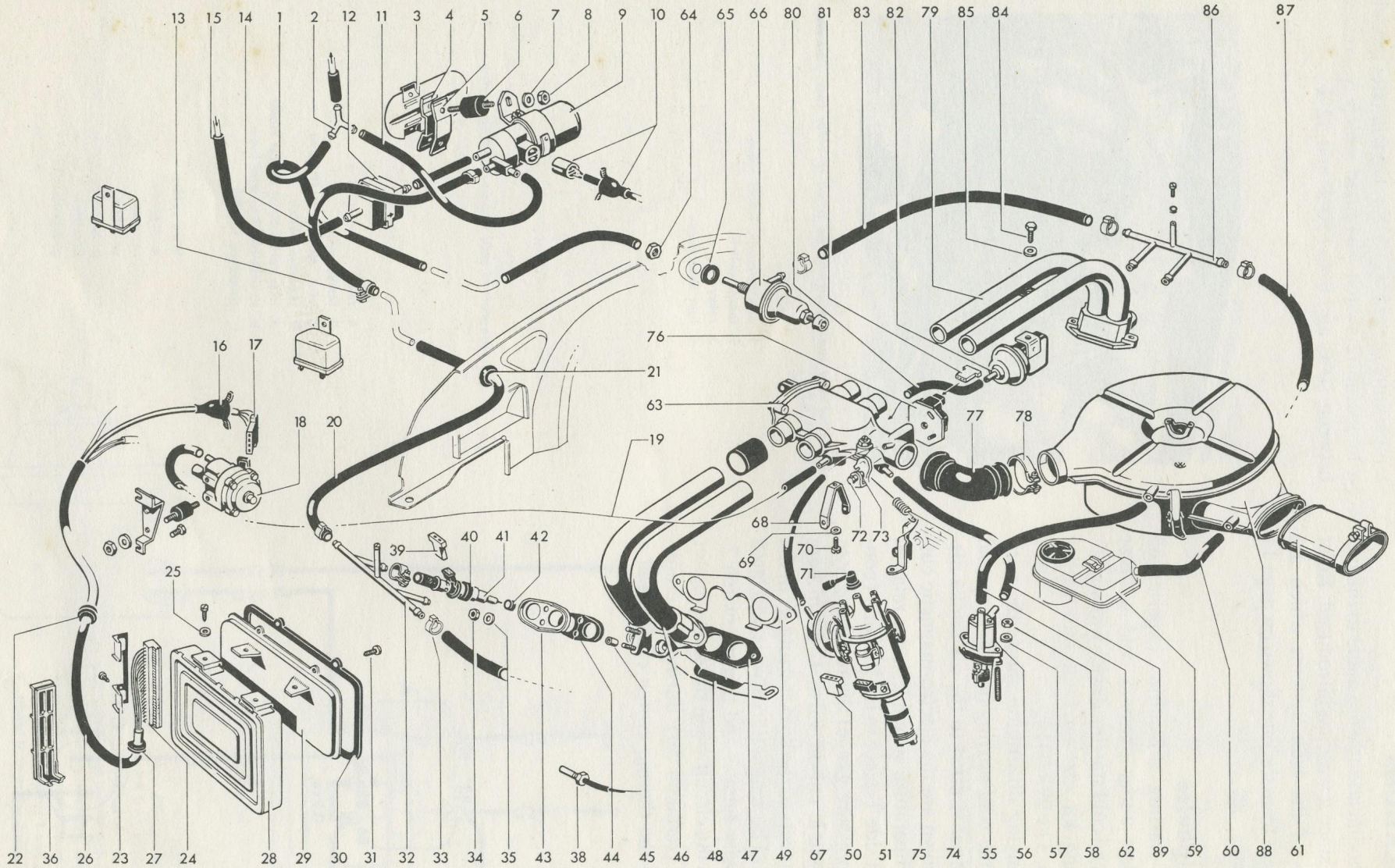


Power and torque curves for the fuel injection engine (A and B). Values are given in DIN Standards

ENGINE POWER AND TORQUE CURVES

The power (A) and torque (B) curves for the fuel injection engine are shown in the accompanying diagram. The fuel injection engine develops its maximum power of 54 hp (DIN Standards) at 4000 rpm. The SAE equivalent is 65 bhp at 4600 rpm. Maximum torque (SAE Standards) is 87 lb-ft at 2800 rpm. In the diagram shown above the torque values are given in mkg. When converting these values to lb-ft, remember that 1 mkg equals 7.2 lb-ft.

1. fuel hose
2. Y-piece for fuel hose
3. shield plate for fuel pump
4. clamping plate
5. bracket
6. bonded rubber mounting
7. washer
8. nut
9. electric fuel pump
10. plug connection and cap
11. fuel hose
12. fuel filter
13. hose clamp
14. fuel hose (pressure side)
15. fuel hose (filter-fuel tank)
16. protective cap
17. 4 prong plug
18. pressure sensor
19. hose (pressure sensor-intake air distributor)
20. fuel hose (to engine)
21. grommet
22. grommet (wire harness)
23. grip for multiple prong plug
24. multiple prong plug
25. nut and washer
26. wire harness
27. rubber sealing ring
28. electronic control unit
29. cover
30. cover gasket
31. screw
32. fuel line distributor
33. clamp
34. nut
35. washer
36. end cover
38. temperature sensor (cylinder head)
39. 2 prong plug
40. outer bushing for injector
41. electromagnetic fuel injector
42. inner bushing for injector
43. retainer plate for injector
44. base plate for injectors
45. sleeve 8 x 12
46. intake manifold
47. manifold gasket
48. cover plate (outer)
49. cover plate (inner)
50. plug
51. ignition distributor
55. seal for auxiliary air regulator
56. auxiliary air regulator
57. washer
58. nut
59. crankcase vent box
60. hose to aircleaner
61. connecting piece
62. connecting hose
63. intake air distributor
64. nut for pressure regulator
65. seal for pressure regulator
66. pressure regulator
67. hose (ign. distributor-intake air distr.)
68. bracket
69. washer
70. screw
71. high tension cable plug
72. clevis pin for throttle valve cable
73. throttle valve lever
74. return spring
75. spring bracket
76. throttle valve switch
77. elbow piece
78. clamp
79. intake manifold
80. hose (pressure switch-intake air distr.)
81. plug
82. pressure switch
83. fuel hose
84. screw
85. washer
86. fuel line distributor
87. fuel hose
88. aircleaner
89. hose (auxiliary air regulator-intake air distributor)



Components of the fuel injection system. Legend is shown on opposite page

LATE MODIFICATIONS

Some detail modifications were made to the fuel injection system since it was first introduced. Refer to the diagrams of the later systems which are somewhat different from the one shown on page 11 for the first system.

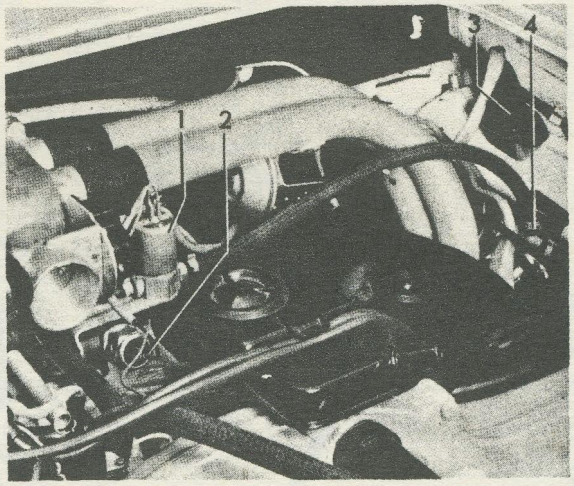
Cold starting device

To alleviate starting difficulties experienced with some models under extreme cold weather conditions a special cold starting device was added. This cold starting kit can be built into earlier models (part No. 311 998 041).

The accompanying illustration shows the various elements of the cold starting device. A special cold starting fuel jet is fitted to the air intake distributor. Also shown are the electro-magnetic cut-off valve 1, a temperature switch 2 and a relay 3.

From the right side T-piece in the fuel line (connection for test pressure gauge) the fuel hose connects to the magnetic cut-off valve 1. From here another hose connects to the cold starting jet in the intake manifold. The magnetic valve is activated in combination with relay 3 and thermo switch 2.

Relay 3 closes the circuit when the starter motor receives current (terminal 50) during the cranking process, and the thermo switch clicks in at a temperature of –15°C (5°F). On still later models a temperature switch was fitted which responded between 10°C and 0°C (50°F and 32°F).



A special cold starting kit can be fitted to older cars. Part No. 311 998 041

1. electro-magn. cutoff valve
2. temp. switch
3. relay
4. fuel hose conn.

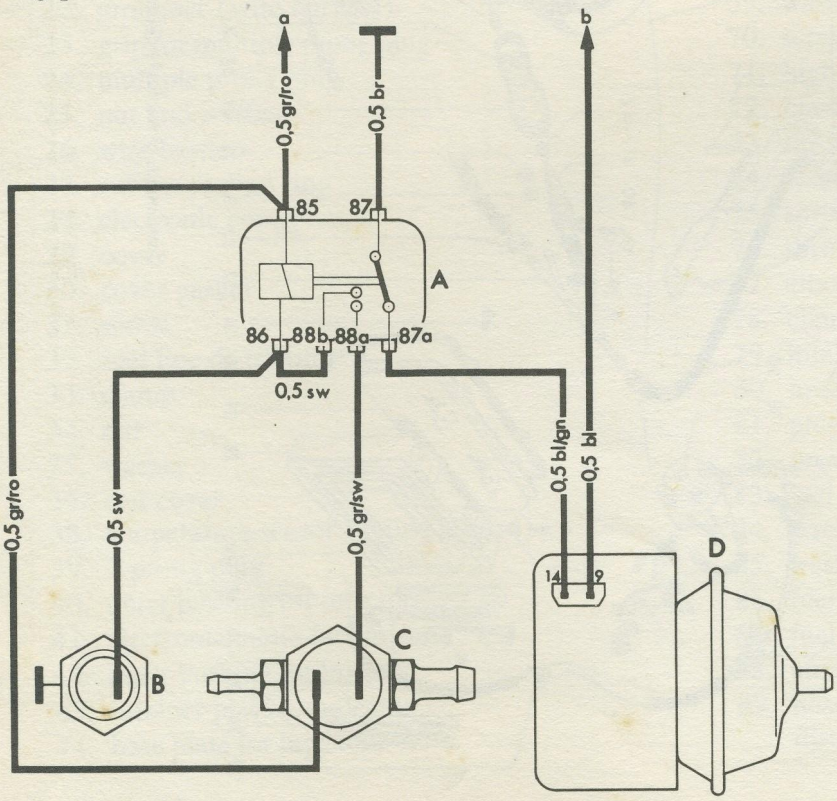


Diagram of cold weather starting device

A. relay
B. temp. switch
C. elec. magn. cutoff valve
D. pressure switch
a. to terminal 50 of starter motor
b. to wire No. 9 of wire loom (pressure sensor)

Wire colors:
gn=green
ro=red
sw=black
br=brown
bl=blue
gr=gray

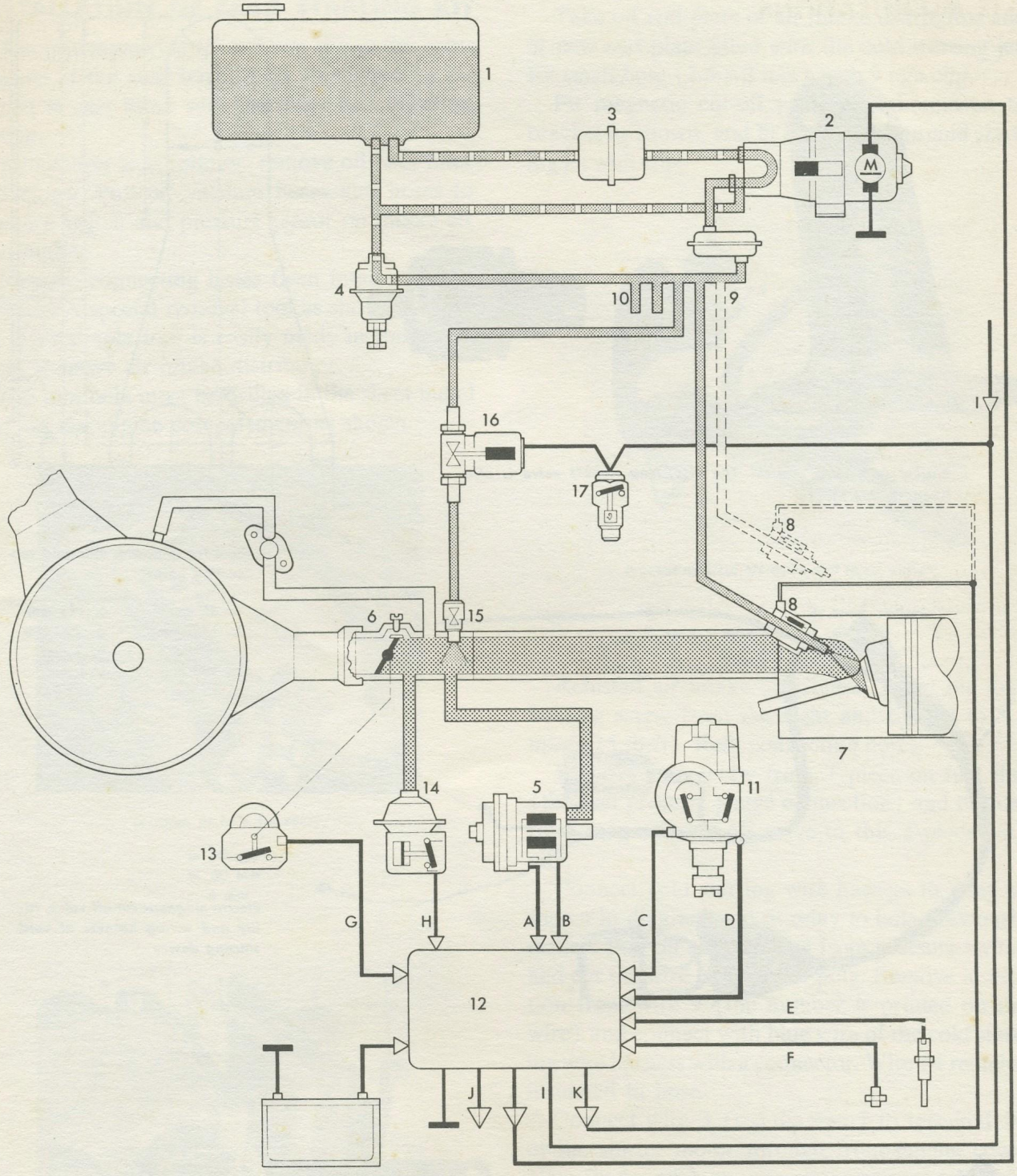
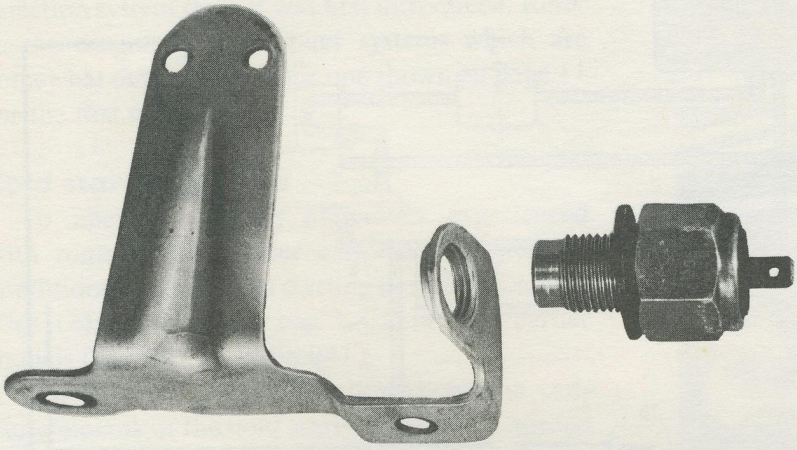


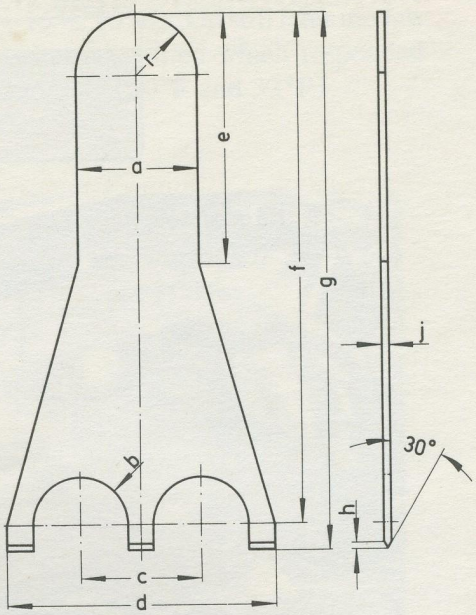
Diagram of fuel injection system with extra provision for operation of cold starting jet

1. fuel tank
2. electric fuel pump
3. fuel filter
4. fuel pressure regulator
5. pressure sensor
6. air intake distr.
7. cylinderhead
8. fuel injectors
9. fuel loop line
10. conn. for fuel line (cold starting)
11. ign. distr. with trigger contacts
12. electronic control unit
13. throttle valve switch
14. pressure switch (no longer used)
15. cold starting jet
16. elec. magnetic valve (cold starting)
17. temp. switch (cold starting)

A and B. signals from pressure sensor
C and D. signals from trigger contacts
E and F. signals from temp. sensors
G. signal from throttle valve switch
H. signal from pressure switch
I. signal from starter (term 50)
J. signal to injectors 1 and 4
K. signal to injectors 2 and 3

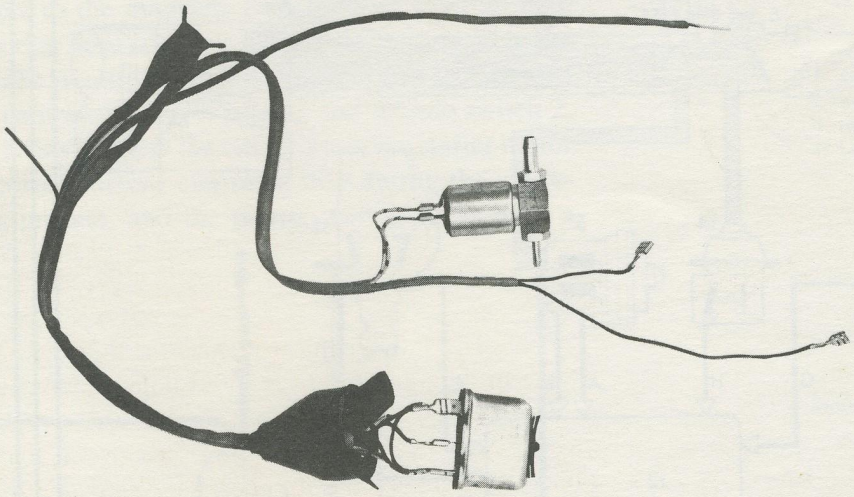


Bracket and temp. switch. The elec. mag. cut-off valve is also fitted to this bracket

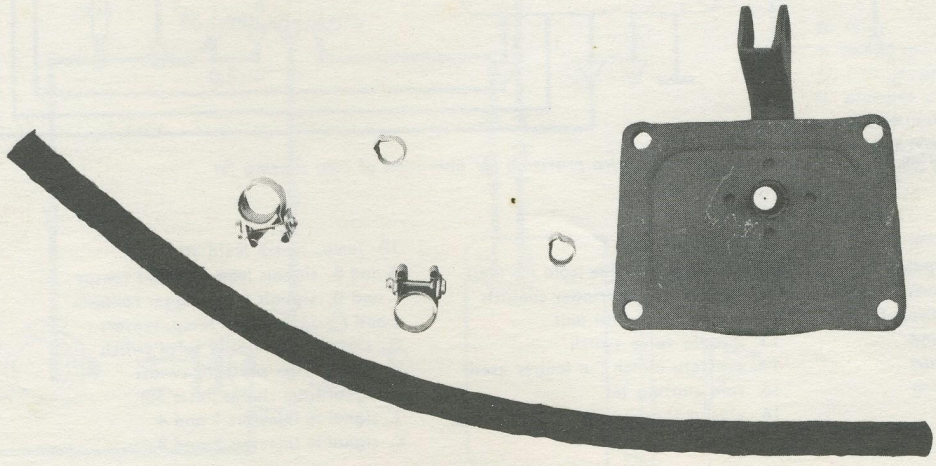


Tool for removing manifold connecting hoses

a. 45 mm	f. 190 mm
b. 17.5 mm	g. 200 mm
c. 45 mm	h. 2 mm
d. 100 mm	j. 3 mm
e. 93 mm	



Electro-magnetic cut-off valve, relay and wiring harness of cold starting device



End cover plate with jet, hose and clips

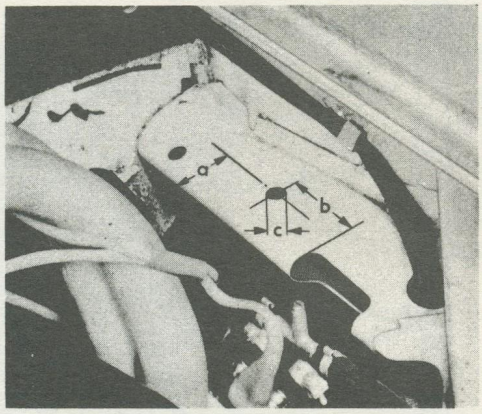
INSTALLATION OF COLD STARTING KIT

The accompanying illustration shows the components of the cold starting kit which can be installed in cars fitted with the older fuel injection system.

Installation is as follows: remove oil bath filter and elbow. Pull off vacuum hoses and hoses to pressure switch and pressure sensor on intake air distributor.

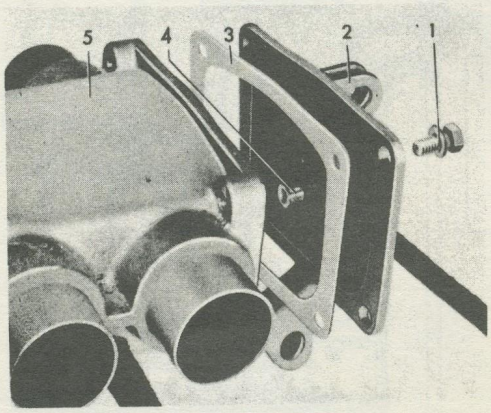
Remove connecting hoses from intake air distributor. A special removal tool as shown is helpful. This simple tool is easily made in the workshop. Remove air intake distributor.

A 6 mm hole must be drilled in the sheet metal plate in the engine compartment as shown.



Location of hole for relay

a. 30 mm
b. 50 mm
c. 6 mm

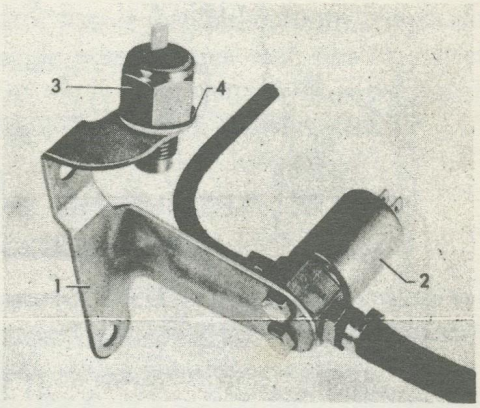


The cold start jet is fitted in the cover plate of the air intake distributor

1. screw and washer
2. cover plate
3. gasket
4. jet
5. air int. distr.

Take off end plate of air intake distributor and fit new end plate fitted with the cold starting jet. Fit small hose (3.5 x 2 mm) with 9 mm clip.

Fit magnetic cut-off valve and thermostat to bracket as shown, and fit hose from the cold starting jet with clip.



Bracket with cut-off valve and temp. switch

1. bracket
2. cut-off valve
3. temp. switch
4. washer

Reinstall air intake distributor. Insert the long holding screw from the right and tighten to 3.5 mkg (25 lb-ft). Refit connecting hoses.

Remove stop screw from T-piece on fuel line (the fuel pressure gauge connection) and fit hose from magnetic cut-off valve to this T-piece with clip.

Connect cold starting wire harness to relay as shown in diagram and fit relay to hole previously drilled. Pull off electric plug from pressure switch and cut the wire close to the plug. Remove insulation from wire 9 (the number is printed on the wire) and connect with blue wire of the cold starting wire harness with a connector. Wire 14 remains insulated in hose.

Connect wire 3 (see diagram) to terminal 50 of the starter motor through front engine cover plate. Fit flat push-on connector and connect wires.

To the existing connector of wire 11 of injection system harness (ground) a second connector must be fitted. To this second connector the brown ground wire of the cold starting device is fitted.

Connect the wires for the magnetic cut-off switch and the thermo switch.

Fit hoses to intake air distributor and install oil bath filter.

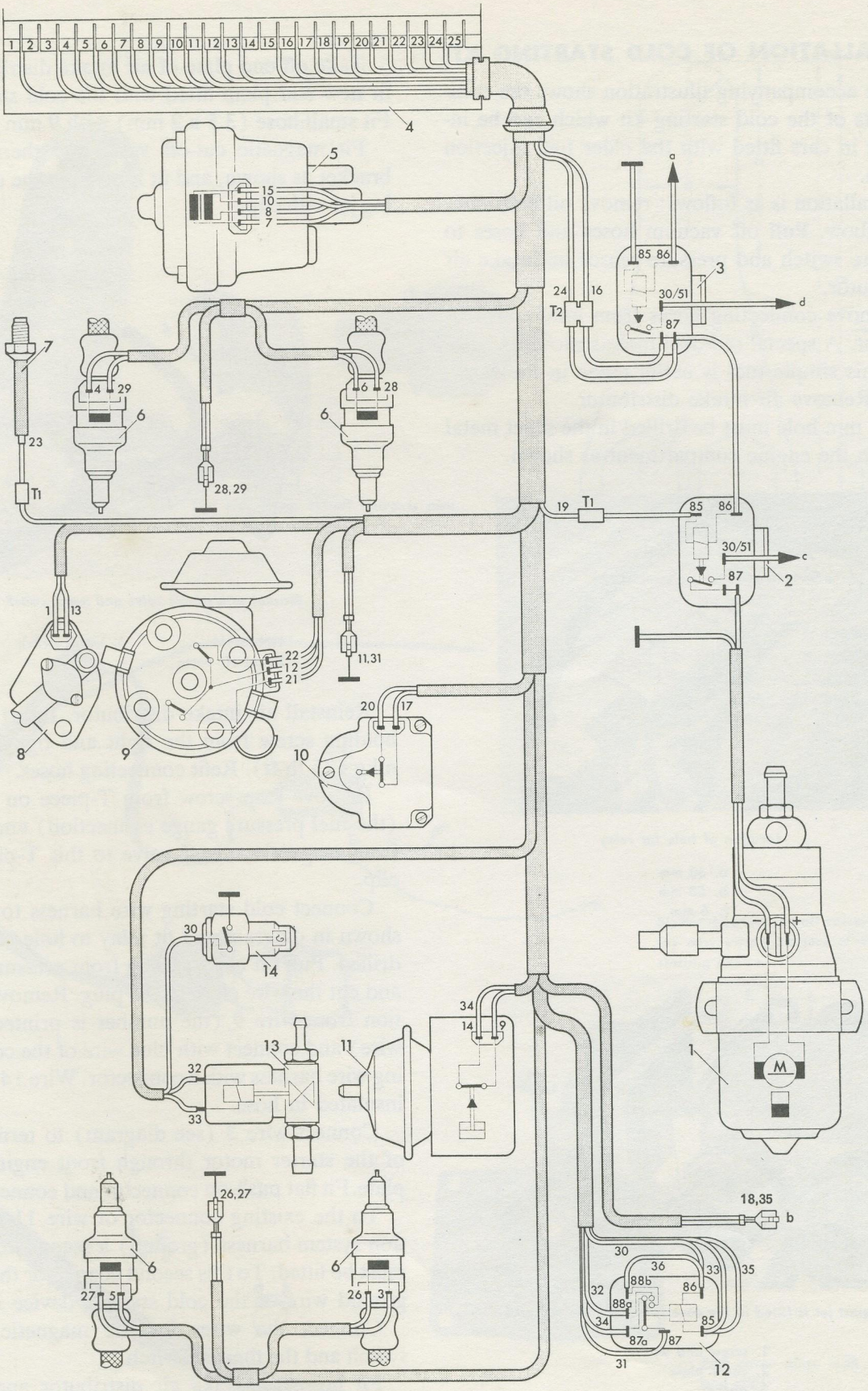


Diagram of modified fuel injection system

1. electric fuel pump
2. pump relay (relay I)
3. voltage supply relay (relay II)
4. electronic control unit
5. pressure sensor
6. elec. magnetic fuel injectors
7. temp. sensor (cyl. head)
8. temp. sensor (crankcase)
9. ign. distr. with trigger contacts
10. throttle valve switch
11. pressure switch (no longer used)
12. relay (cold starting jet)
13. elec. magnetic cutoff (cold starting jet)
14. thermo switch (cold starting)

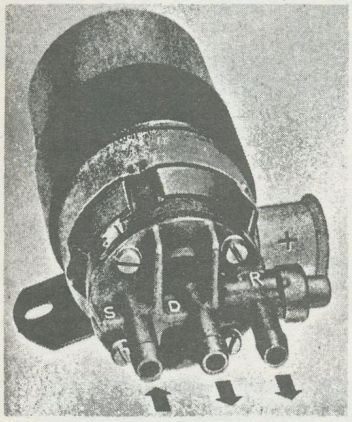
a. wire to ign. switch (terminal 15)
b. wire to starter solenoid (term. 50)
c. wire to terminal 30
d. wire to pos. battery terminal

MODIFIED ELECTRONIC CONTROL UNIT

A modified control unit is used in the latest models. Inasmuch as the new circuitry is adapted to the new elements used in the system, it cannot be fitted to older models. (Part No. 311 906 921 C).

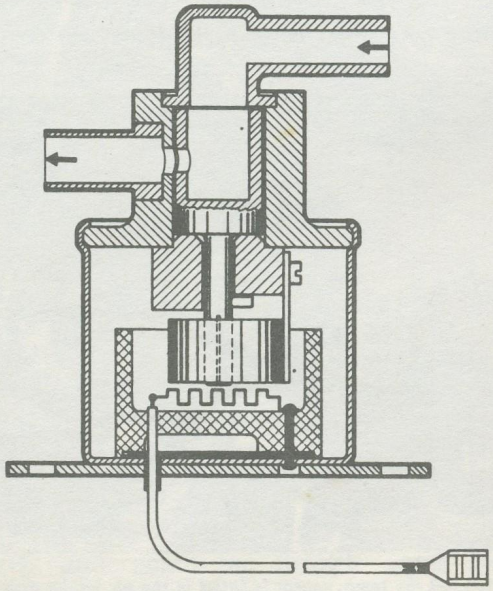
NEW FUEL PUMP

The latest models are fitted with a new type fuel pump. It has different hose connections as shown. The electric motor is submerged in the fuel and there is now no separation between the motor and the pump. This new pump can be fitted to older vehicles.



S. suction line
D. pressure line
R. return line

Latest type electric fuel pump. This pump can be installed to earlier models



Auxiliary air reg. with electric heating is used for type 3 models with automatic transm. and type 4 models

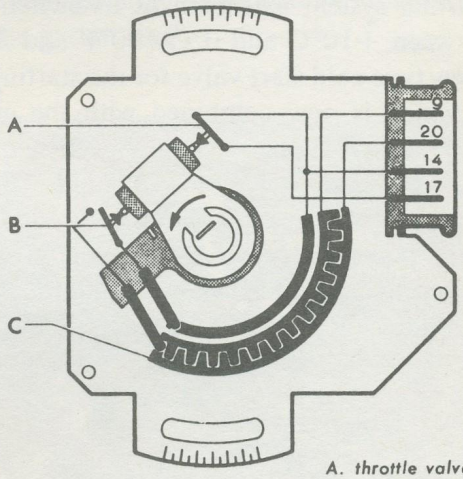
MODIFIED AUXILIARY AIR REGULATOR

A modified auxiliary air regulator is fitted to later models. A sectional view is shown. The new regulator has additional electric heating through an electric heating element connected to terminal 15 of the ignition coil. The bimetal spring in the air regulator thus is responsive to the temperature in the engine compartment and also to the temperature of the heating element. It is not possible to install this regulator in older models.

MIXTURE ENRICHMENT FOR ACCELERATION

Also new for the later models is a provision for mixture enrichment to insure quick acceleration (conditions of high manifold pressure).

It takes the form a special throttle valve switch (modified and more elaborate than the earlier design) and new electronic circuitry in the control unit. A sectional view is shown.

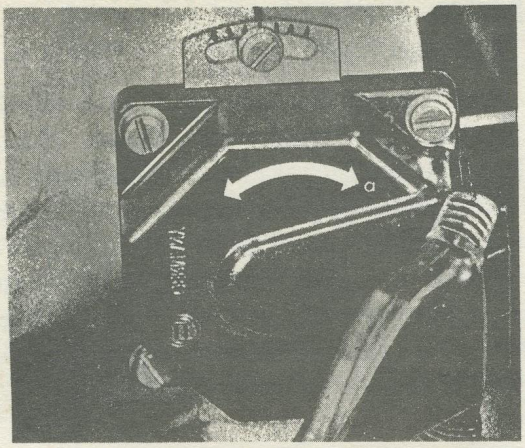


New type throttle valve switch

A. throttle valve switch
B. switch
C. contact strips

Aside from switch A which as before regulates fuel shut off during deceleration, it also includes the two contact strips C. When the throttle valve opens, the various contact points on segments C come into play and so transmit impulses to the control unit which then decides on the correct fuel dosage for the prevailing conditions.

It is the duty of switch B to only close the circuit when the throttle valve is opened. The new throttle valve switch now has four electrical connections cannot be built into older engines (part No. 311 906 111 C).



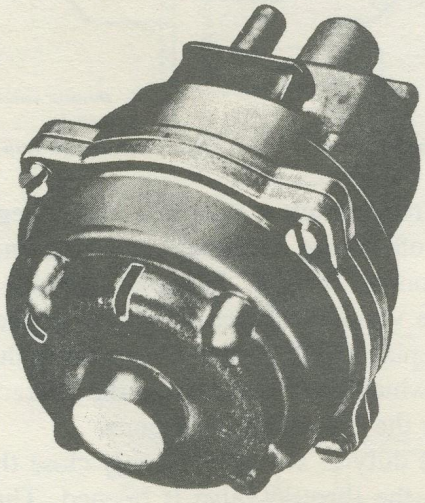
New type throttle valve switch with provision for signalling mixture enrichment for high power requirements

LATEST COLD STARTING DEVICE

The latest models have yet another type cold starting device which is different from the one described previously.

The new system, which is a standard fitting to all models has a new temperature switch (part No. 311 906 161 A). It should not be built into the old starting system inasmuch as its switch point lies between +10°C and 0°C (50°F and 32°F).

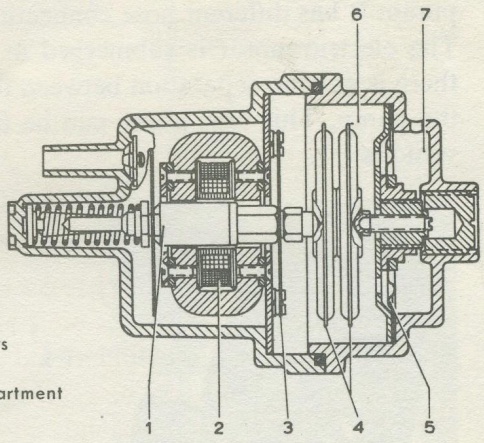
A new type cold start valve for the starting jet is fitted, which is now combined with the electromagnetic switch. It receives its current from terminal 50 of the starter motor solenoid. The temperature switch closes the circuit to ground when its switch point is reached. The new cold starting jet is fitted under and between the inlet manifolds on the right hand side.



New type pressure sensor. This unit cannot be used on older models

NEW TYPE PRESSURE SENSOR

A new type pressure sensor is used for the latest models. A sectional view is shown. This unit signals the need for extra fuel enrichment for high power requirements (high manifold pressure). It does in fact combine the duties of the old type pressure sensor (described on page 13) and the pressure switch described on page 15. The pressure switch is no longer used in the latest models. Part No. of the pressure sensor: 311 906 051 C.

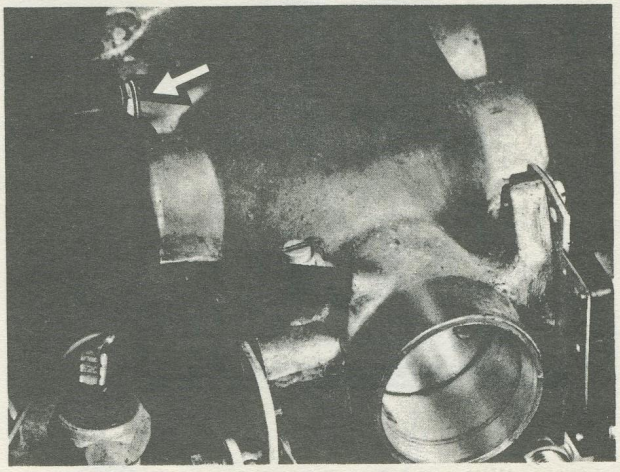


1. armature
2. coils
3. spring
4. aneroid bellows
5. diaphragm
6. pressure compartment
7. atm. pressure

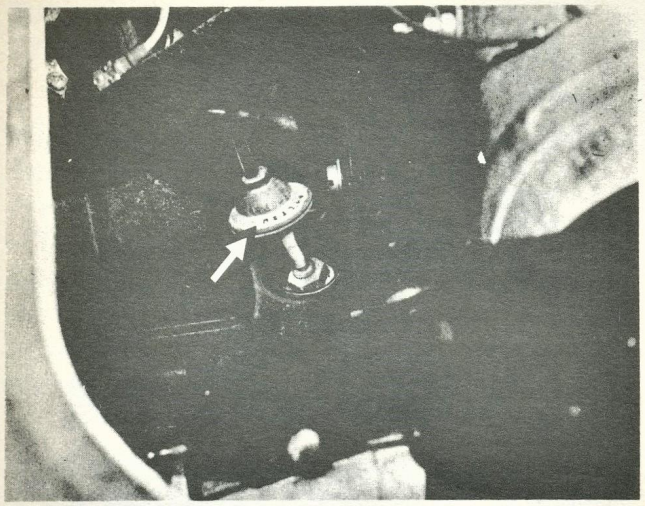
Latest type pressure sensor has two aneroids and an additional diaphragm

TEMP. SENSOR I FOR TYPE 3 MODELS (AS OF AUG '69)

Temp. sensor I on cars built after Aug '69 is positioned in the air intake distributor as shown. A sealing ring must be used (see arrow).



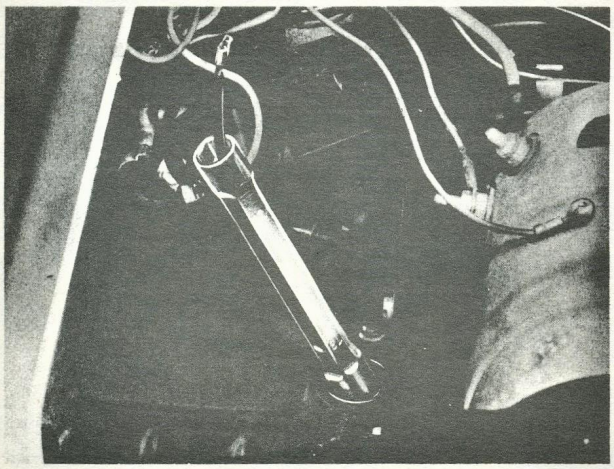
As of Aug '69 the temp. sensor is fitted in the air intake distributor. Don't forget sealing ring



As of Aug. '69 temp. sensor is located between cylinders 3 and 4. Arrow indicates sealing cap

TEMP. SENSOR II FOR TYPE 3 MODELS (AS OF AUG '69)

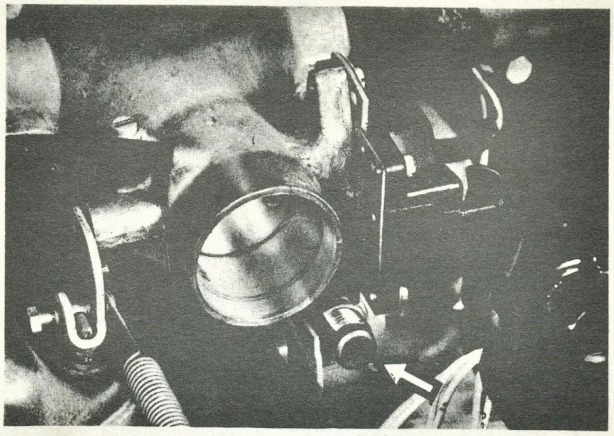
Temp. sensor II on cars built after Aug '69 is now situated in the cylinderhead between cylinders 3 and 4, and can be reached in the engine compartment. To remove, slide cover cap over the connecting wire, and with 13 mm socket wrench over the wire as shown, unscrew sensor.



As of Aug '69 temp. sensor II is fitted between cylinders 3 and 4 Temp. sensor can be unscrewed with 13 mm socket wrench

TEMP. SWITCH FOR TYPE 3 MODELS (AS OF AUG '69)

The temp. switch on later models is situated directly underneath the throttle valve switch as shown. It can be unscrewed with a 24 mm open end wrench.

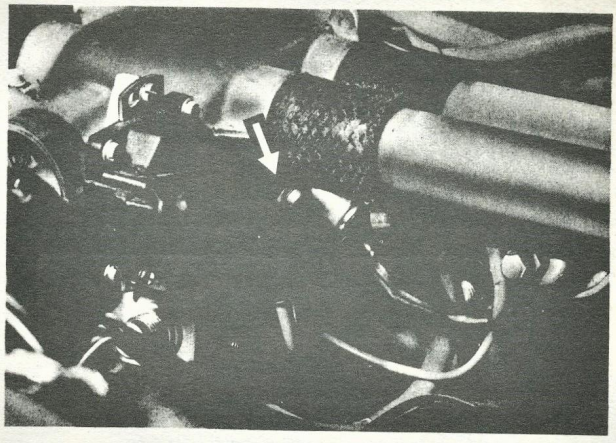


Temp. switch is situated underneath throttle valve switch (as of Aug '69)

COLD STARTING JET (TYPE 3 AS OF AUG '69)

The cold starting jet on later types is situated in the air intake distributor underneath the manifolds of cylinders 1 and 2. The jet assembly can be taken off after the two mounting screws are removed. Pull hose off carefully.

When installing, first push on hose. Do not forget the gasket ring.



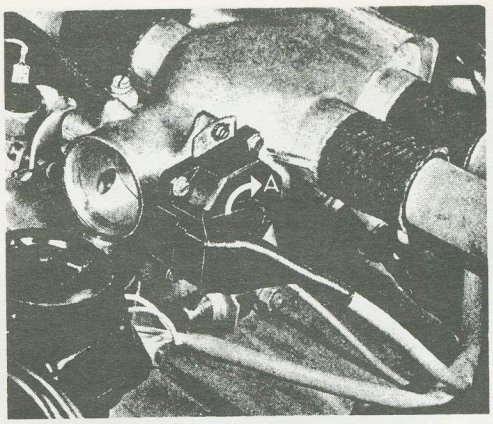
Cold start valve is fitted on the right side underneath manifold (as of Aug '69)

ADJUSTMENT LATE TYPE THROTTLE VALVE SWITCH (TYPE 3)

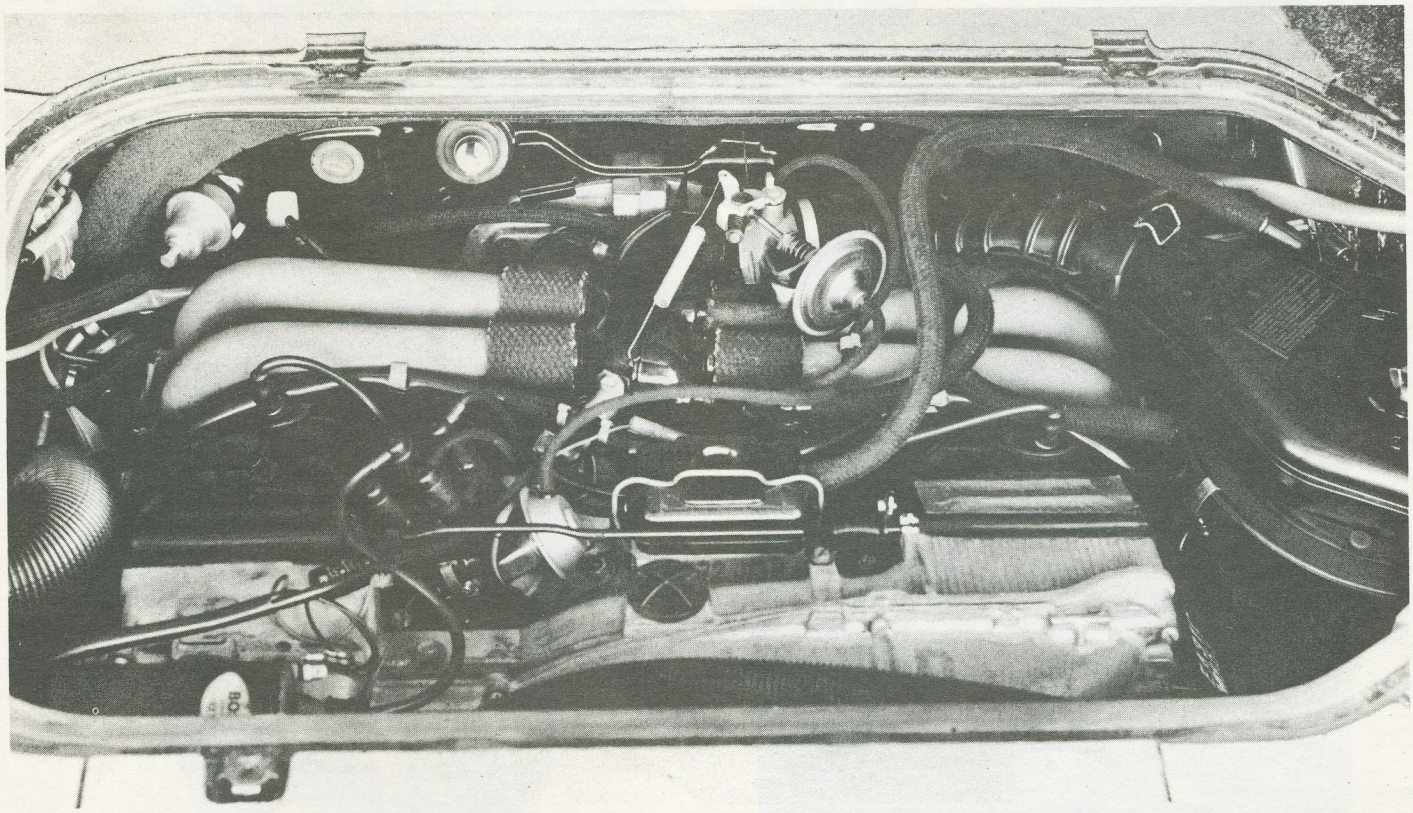
The throttle valve switch is adjusted with tester EFAW 228 as follows: remove control unit. Connect tester 228 (or 193 with adapter) and switch to position "Throttle valve switch III." Switch A in position "Measuring."

Switch on ignition. Close throttle valve. Rotate switch body in direction A as shown until tester indicates 0 Ω. Now rotate throttle valve switch a further 2°. Tighten screws.

When the throttle valve switch is just cracked open, the tester should indicate ∞.



The throttle valve switch must be rotated in direction of arrow (late type 3)



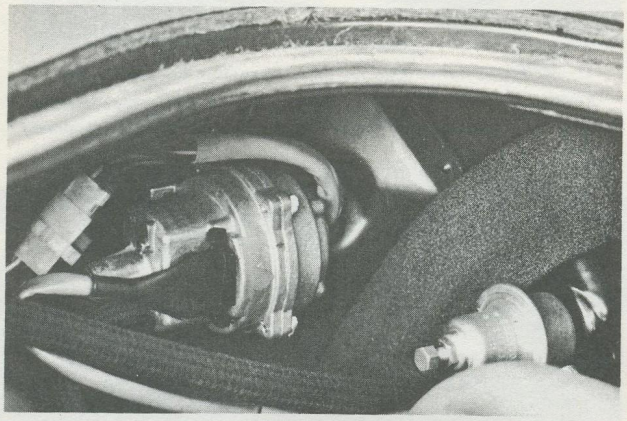
Engine compartment of type 4 Variant (1971 model)

FUEL INJECTION SYSTEM TYPE 4 MODELS

The type 4 fuel injection system is very similar to that of type 3 models, but there are detail differences. See accompanying diagrams.

Pressure sensor

The pressure sensor is mounted on the left side of the engine compartment. It looks exactly like the one used for type 3 models, but it has different characteristics. It must be mounted in a horizontal position.



Pressure sensor is fitted on the left side in the engine compartment

Throttle valve switch

The throttle valve switch is fitted underneath the throttle valve housing. To remove, proceed as follows: remove air filter assembly. Unhook throttle valve spring. Loosen throttle valve cable (use 2.5 mm Allen wrench). Unscrew the throttle valve housing mounting screws (arrows) and take off assembly.

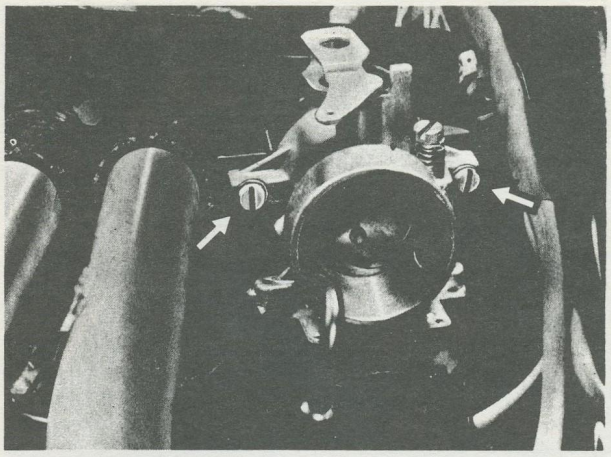
ADJUSTMENT THROTTLE VALVE SWITCH

Adjustment of the throttle valve switch depends on whether or not fuel shut off on coasting is used. On cars without fuel shut off, terminal 17 of the switch is not connected.

Adjustment with fuel shut off

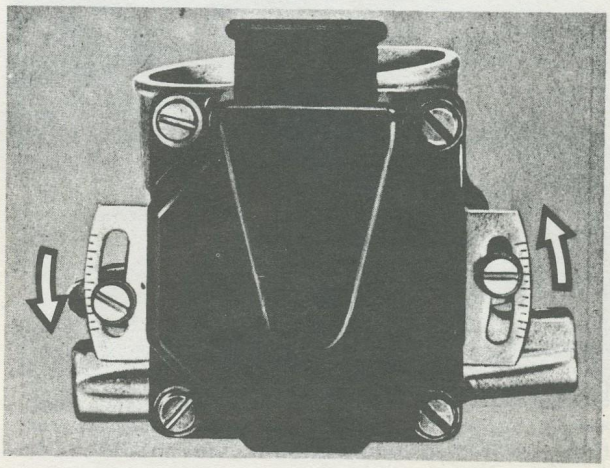
With the throttle valve housing removed, proceed as follows: connect tester 228 (or 193 with adapter). Switch A in position "Measuring." Switch B in position "Throttle valve III."

Put the switch on the throttle valve shaft and tighten screws loosely. Push on plug and switch on ignition. Rotate the switch until the needle of the



On type 4 models, the throttle valve switch is fitted underneath the throttle valve housing. Arrows point to housing retaining screws

tester goes from ∞ to 0. Now rotate switch one graduation (2°) counter clockwise. Tighten screws and check for correct operation.



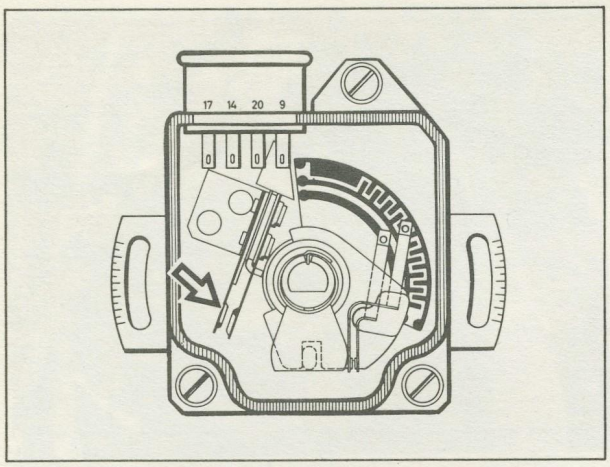
The throttle valve switch must be rotated in direction of arrows

Adjustment (no fuel shut off)

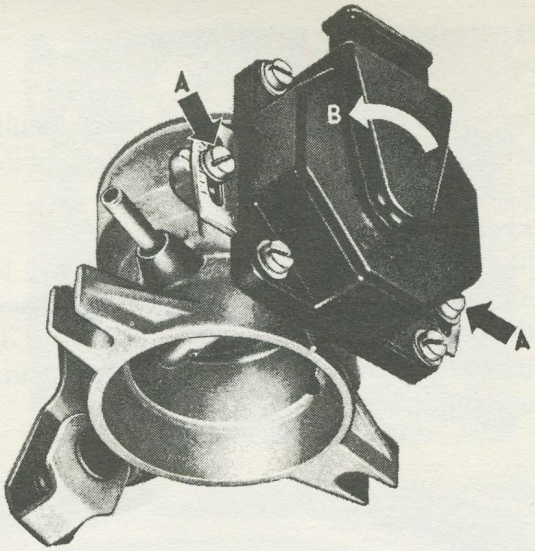
Connect tester. Switch on ignition. Switch tester 228 (or adapter) to position "Throttle valve switch I." Open throttle valve slowly. Needle of tester should move 9 to 10 times between 0 and ∞. Repeat test with tester on position "Throttle valve switch II." Reposition switch as required.

A check on the adjustment can be made by opening the switch. Loosen the 4 screws and carefully take off cover. Do not pull at the plug. With correct adjustment, the contact (arrow) should be just about to close.

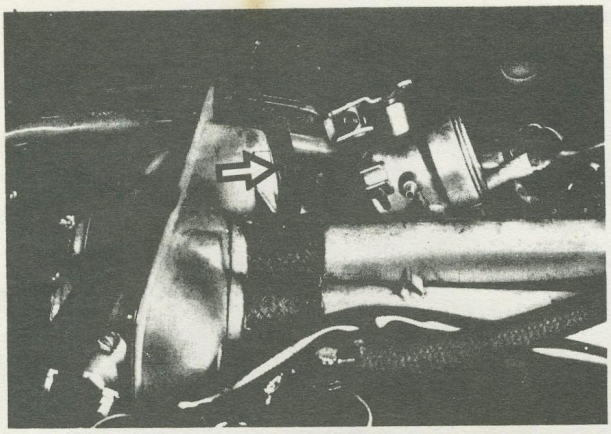
When reinstalling the throttle valve housing, make sure rubber sleeve is positioned correctly. Do not overtighten the mounting screws.



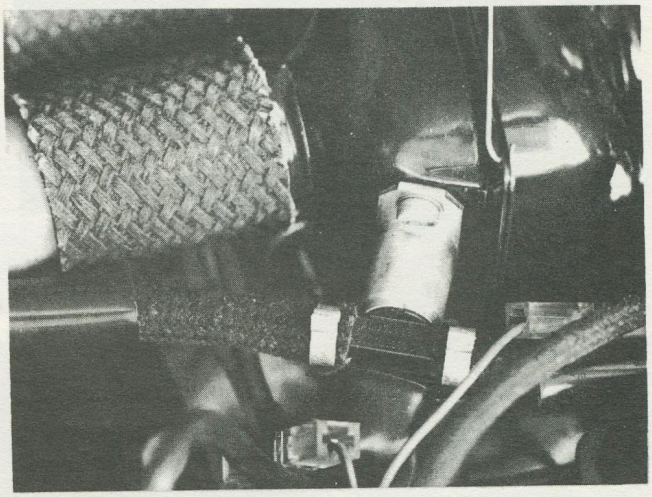
Throttle valve switch opened up. Arrow points to contact points



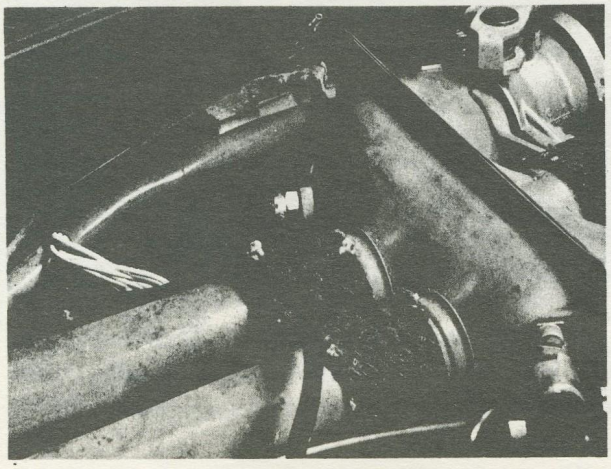
Throttle valve body with switch. Arrow A indicates retaining screws of the switch. Arrow B indicates direction of adjustment rotation



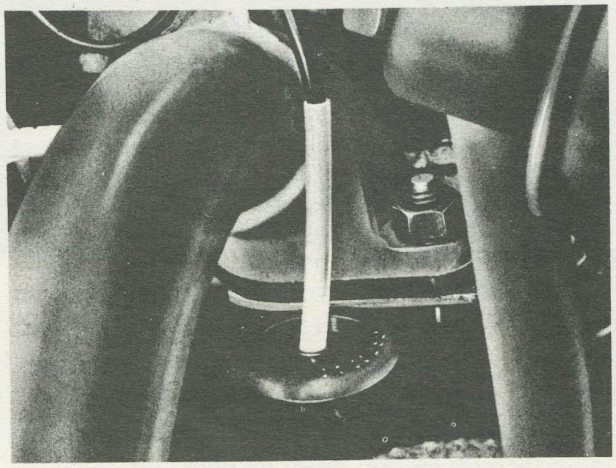
The air intake distributor on type 4 models is made out of sheet metal. Arrow points to rubber sleeve between distributor and throttle valve housing. Do not overtighten screws



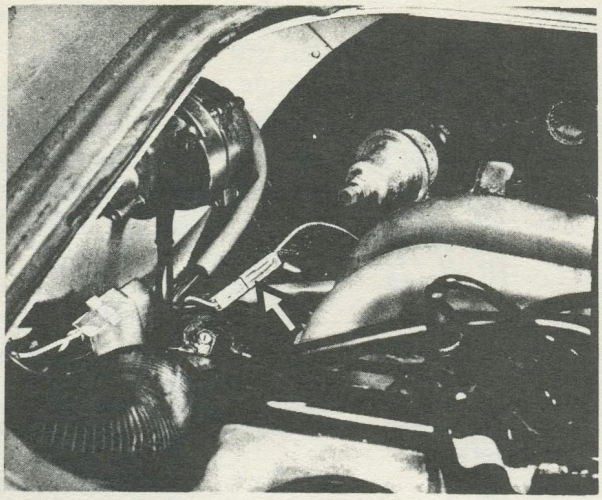
Cold start valve is fitted to the rear of the air intake distributor on type 4 engines



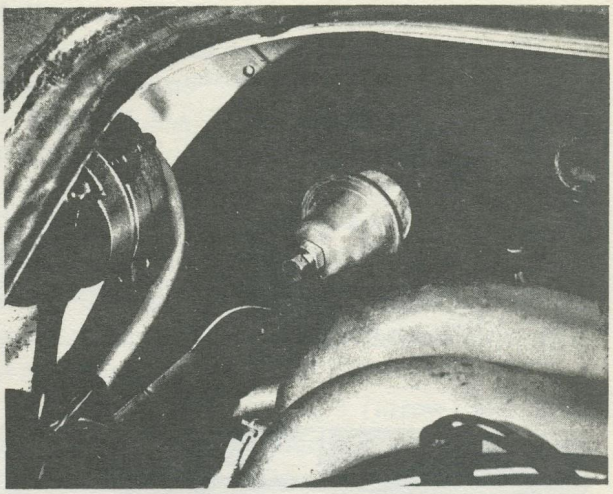
Position of temp. sensor I on type 4 engines



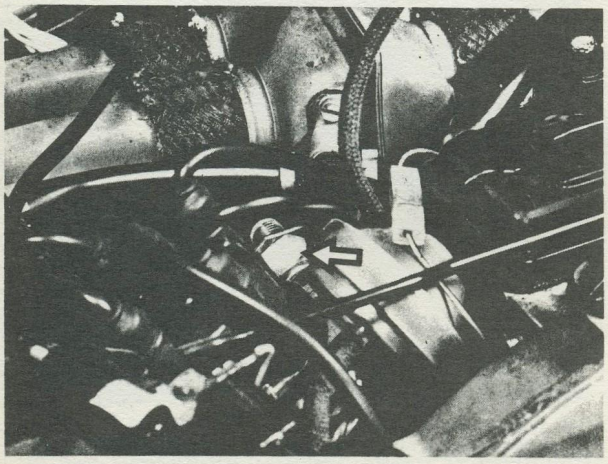
Temp. sensor II is fitted underneath the manifold of No.4 cylinder on type 4 engines



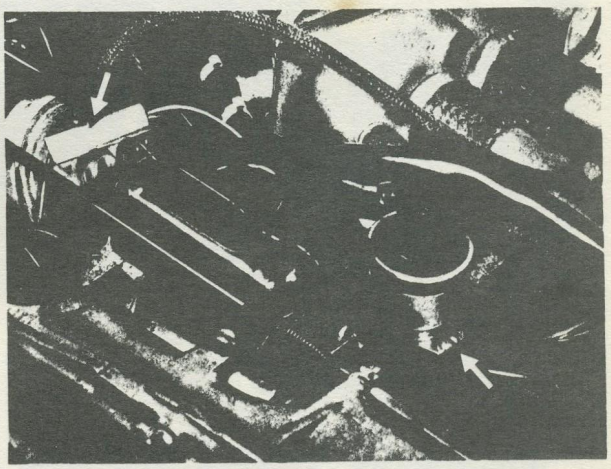
Arrow points to plug connection of temp. sensor II (cyl. head)



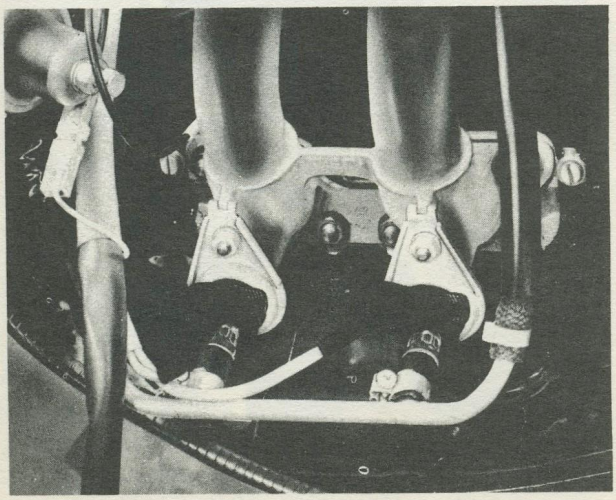
Pressure regulator is fitted on the front engine panel. To remove, jack up vehicle and remove from below with 17 mm open end wrench. Clamp off fuel hoses



Temp. switch (thermo switch) on type 4 models



Aux. air regulator is situated as shown (type 4)



Injectors are located as shown

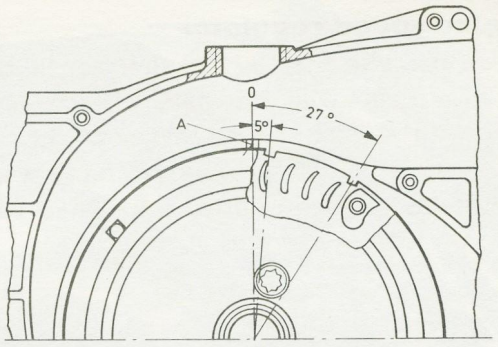
To remove auxiliary air regulator, loosen the retaining nuts (arrow). Disconnect plug connection (arrow). Pull off the two air hoses of the air regulator. Test heating element. The resistance between the connecting plug and regulator housing must be 12.5 ($\pm$1.0) Ω at 20°C (68°F).

When installing, first connect air hoses, then fasten unit.

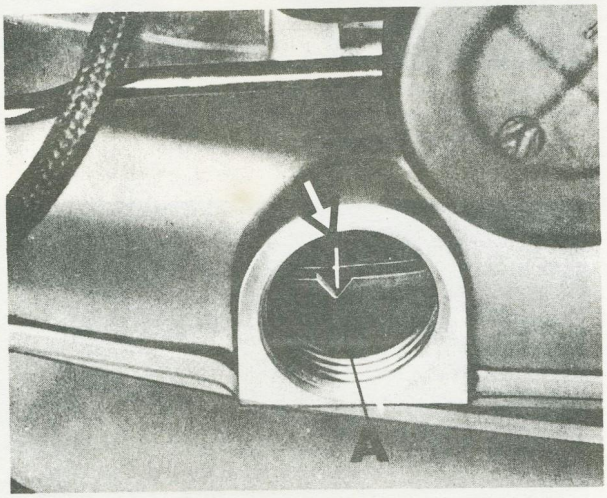
SPARK TIMING 411 ENGINE

The type 4 engine is adjusted to a spark advance of 27° before top center. The red notch on the flywheel is timing mark for 27 before top center at 3500 rpm. The black notch is the timing mark for 5° before top center (static adjustment).

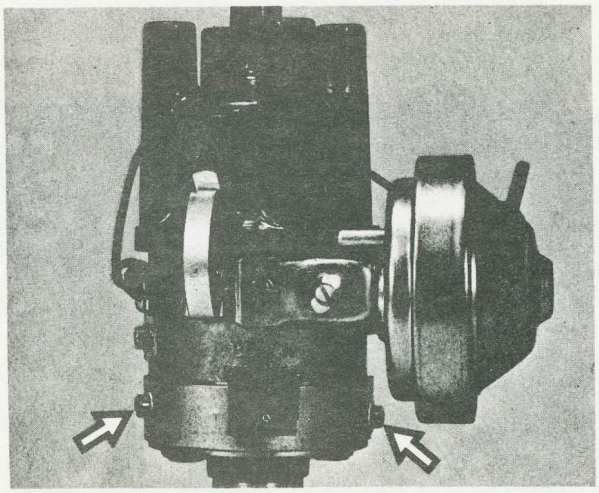
Idle speed: 850 rpm (±50). The engine in the Porsche 914/4 is adjusted to an idle speed of 950 rpm (±50).



Type 4 engines must be adjusted to a spark advance of 27° before top center at 3500 rpm (red notch). The static adjustment is by the black notch (5° before top center). With stroboscopic light check adjustment at 3500 rpm with both vacuum hoses disconnected



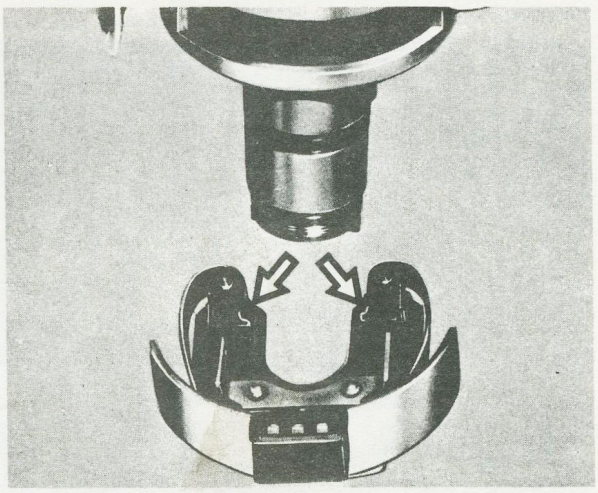
To check on spark timing, remove inspection plug. A: notch in cooling blower housing. Arrow points to spark timing notch



Arrows indicate retaining screws of trigger contact housing

FUEL INJECTION ENGINE SENSITIVE TO VALVE ADJUSTMENT

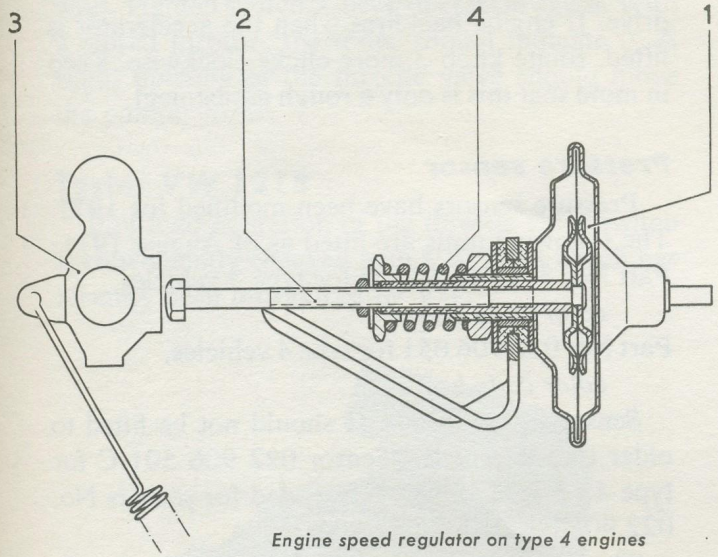
The fuel injection engine is very much affected by valve lash adjustment. If the valves are binding (valve lash insufficient), the engine will idle rough, much rougher in fact than a carbureted engine would under similar circumstances. So, whenever rough idling is experienced (especially with a cold engine), be sure to check the valve clearance.



The breaker levers of the trigger contacts should be lubricated sparingly at the positions indicated by the arrows

Engine speed regulator

Starting with the 1971 model year, all type 4 engines in cars with automatic transmissions are fitted with an engine speed regulator which keeps the engine in the 700 to 750 rpm range when the transmission lever is shifted into Drive (or any other position except Park or Neutral).



Engine speed regulator on type 4 engines

1. vacuum chamber
2. rod
3. throttle valve lever
4. coil spring

The illustration shows the principle of the speed regulator. Vacuum chamber *1* is connected to the air intake distributor. Engine speed is regulated according to the prevailing pressure conditions. Rod *2* actuates throttle valve lever *3*.

When the engine is not running, spring *4* pushes rod *2* against the throttle valve lever to slightly open the throttle valve.

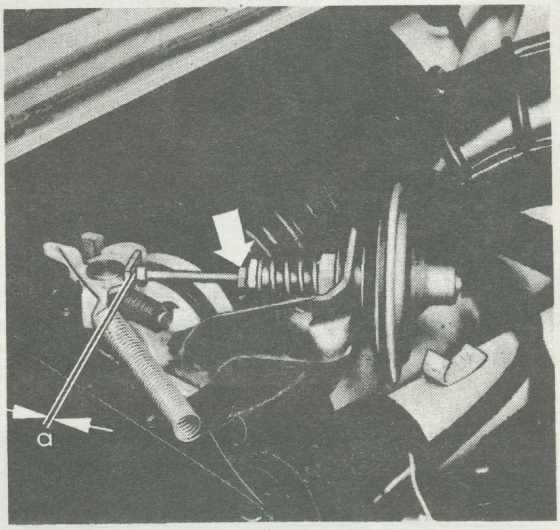
As soon as the engine is running, a depression (partial vacuum) is created in vacuum chamber *1* causing rod *2* to be pulled back. This moves the throttle valve back to the closing position. Thus a balance is reached which keeps the engine rpm in the pre-determined range.

When the transmission lever is now moved into a drive position, the drive torque tends to stall the engine. Diminishing engine speed causes a pressure rise in the vacuum chamber, and rod *2* pushes the throttle valve open causing the engine speeed to rise. Now a new balance is reached which keeeps engine rpm in the 700 to 750 range.

Adjustment of speed regulator on type 4 engines coupled to automatic transmissions

The engine speed regulator is adjusted as follows: be sure that the vacuum chamber is not up against the manifold. Engine oil temp. should be 50°-70° C (122°-158° F). With an engine idle speed of 850 (+50) rpm, there should be a clearance *a* of about .5-1.00 mm (.020-.040 in.) between the screwhead and the throttle valve lever as shown.

To adjust, loosen nut M 5 (arrow) and rotate the M 5 screw as required. After correct adjustment is obtained, tighten nut. With this adjustment, pull up handbrake and shift into a drive position. Engine rpm should drop to about 700 to 750 rpm. In case engine speed is too high, make the required adjustment. There is a possibility that clearance *a* will be larger than 1 mm after satisfactory adjustment has been obtained.



Engine speed regulator on type 4 engines. Arrow points to lock nut

Engine speed regulator for 1972 type 4 models

The spring tension on the regulator for the 1972 type 4 models has been changed. As of engine No. WO 105 249 adjustment is as follows: adjust idle speed to 850 (+50) rpm. Apply handbrake and shift automatic transmission in drive position. Engine speed should drop to about 650 (+50) rpm. Clearance as indicated by the arrow should be about .5-1.0 mm (.020-.040 in.).

1972 MODIFICATIONS (EUROPEAN MODELS)

Some modifications in the F.I. system were made for the 1972 models.

Electronic control unit

The electronic control units have been slightly modified. The type 3 unit carries part No. 311 906 021 E and has a *black* color code.

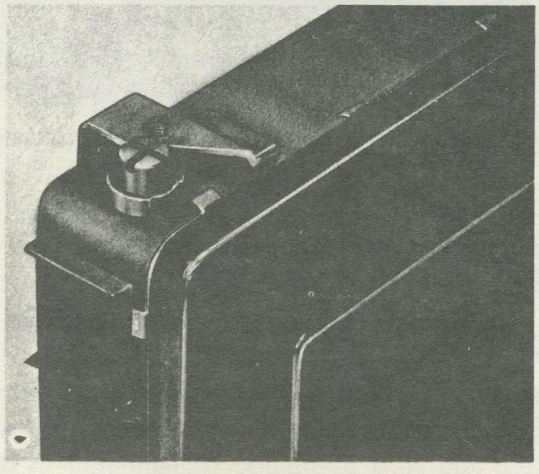
The type 4 unit carries part No. 022 906 021 C and has a *blue* color code.

Unit 311 906 021 E cannot be fitted to older models. For unit 022 906 021 C, unit 022 906 021 E is available as a replacement. This unit can be fitted to older vehicles.

Up until chassis No. 411 2000001 thermo-switch 311 906 161 C has to be used also. Control unit 022 906 021 E is fitted with an adjustment to control CO emission. By turning the adjustment knob the CO content in the exhaust gases is adjusted at idle speed. If this unit is installed, it will be necessary to adjust for low CO emission.

Adjustment is as follows: adjust spark timing, valve lash, throttle valve switch. Connect the exhaust gas analyzer according to the manufacturer's instructions.

Start engine and let it run until the oil temp. reaches 50°-70° C (122°-158° F). Idle speed with closed throttle valve must be 850-900 rpm. Turn adjusting knob until satisfactory adjustment is obtained, i.e. about .7% volume content.



New control unit with adjusting knob on top

Adjustment without analyzer (approximate adjustment)

If an analyzer is not readily available, an approximate adjustment can be made as follows: adjust spark timing, valve clearance and throttle switch as above. Turn adjusting knob counter clockwise up against the stop, then turn knob 12 clicks in a clockwise direction. Take car for a test drive. If engine backfires when the accelerator is lifted, rotate knob 3 more clicks clockwise. Keep in mind that this is only a rough adjustment.

Pressure sensor

Pressure sensors have been modified for 1972. The following units are fitted as of August 1971:
Part No. 311 906 051 D for type 3 vehicles,
color code green
Part No. 022 906 051 for type 4 vehicles,
color code brown

Sensor 311 906 051 D should not be fitted to older type 3 vehicles. Sensor 022 906 501 C for type 4 vehicles can be substituted for sensors No. 022 906 051 B and 022 906 051 A.

The type 3 pressure sensor no longer has provision for full load mixture enrichment. This duty has been taken over by the throttle valve switch.

A further modification is that the latest sensor is provided with an altitude mixture corrector, making the required mixture adjustments according to altitude.

New sensors are grounded

The sensors are now grounded. The sensor body has a connection for attachment of a ground wire to the engine crankcase. This modification has been made to eliminate intruding electrical induction effects caused by the ignition system.

The new sensors are fitted with a double acting flutter valve in the hose connection. Its duty is to make the sensor respond faster to changes in manifold pressure.

Modified throttle valve switch

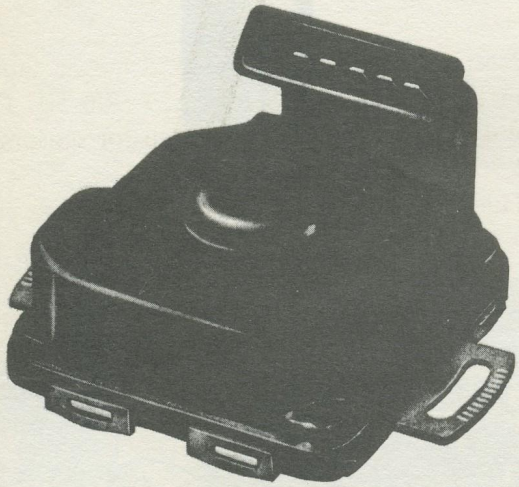
The throttle valve switches for the latest type 3 and type 4 models have been modified. Sealing of the unit has been improved. In addition they now have a 5 prong plug connection. The new units should not be fitted to older models. The fifth connection is for full load enrichment on type 3 models. For the type 4 models, the extra connection is not used.

ADJUSTMENT OF NEW TYPE THROTTLE VALVE SWITCH (TYPE 3 MODELS)

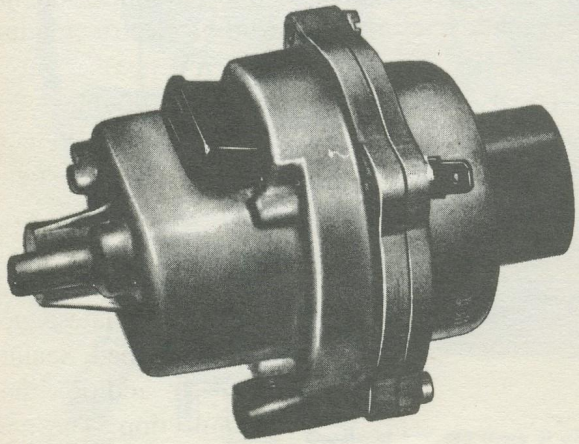
Adjustment of the new throttle valve switch is as follows: switch on ignition. Rotate throttle valve switch counter clockwise until pointer of tester moves from ∞ to 0. From this position rotate unit one division (2 degrees) further counter clockwise. Tighten switch. Check operation again. With a closed throttle, the tester should indicate 0. A slight opening of the throttle valve should move the pointer to ∞.

Tester VW 1218

Full load operation of the throttle valve switch is conveniently checked with VW 1218 which has recently been introduced by VW.



Late type throttle valve switch with 5 prong plug connection



Late type pressure sensor

Modifications to the F.I. system on certain export models (including cars for the US)

The F.I. system on cars exported to countries with very stringent emission control laws (notably the US) varies slightly from the system used on European cars.

Control unit

Modified control units are identified as follows:

Part No. 311 906 021 E for type 3 models, *color code black*

Part No. 022 906 021 E for type 4 models, *color code brown*

These control units should not be fitted to older models. The new units, just like those for the European version are provided with an emission control knob with 23 adjustment positions. Adjustment is as described previously.

Pressure sensor

Pressure sensors also have been modified and are almost identical to those used on European versions. Identification is as follows:

Part No. 311 906 051 E for type 3 models, *color code black*

Part No. 022 906 051 C for type 4 models, *color code brown*

Sensor 311 906 051 E should not be fitted to older models. Sensor 022 906 051 C (also used on European models) can be substituted for 022 906 051 B.

Throttle valve switch (type 3)

The new throttle valve switch has a five prong plug as mentioned earlier. These new units should not be fitted to older models. There is no fuel shut off on the overrun and adjustment is as follows: throttle valve must be closed (idle speed position). Place switch on throttle valve spindle and rotate against stop (clockwise). Further adjustment is as described for the earlier models.

Modified pressure regulator (for type 3 cars destined for California)

The new type 3 cars exported to California are fitted with a modified pressure regulator. These new units should not be fitted to older models.

Modifications to 1972 type 3 and 4 models (cars exported to California)

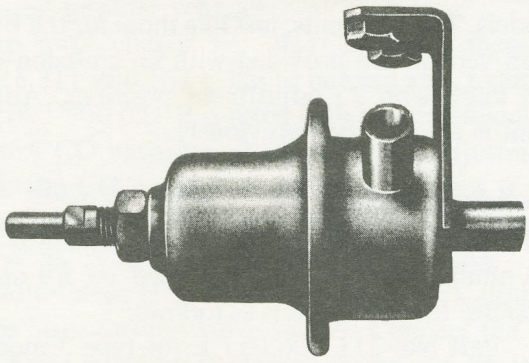
The accompanying illustration shows how the fuel system for type 3 and 4 models has been modified. With this new system extra intake air is provided on the overrun (foot lifted off the accelerator). A pneumatically operated valve *2* is used on manual shift cars and an electro-magnetic valve on cars fitted with automatic transmission (see ill.). Principle of operation is as follows:

Manual shift cars

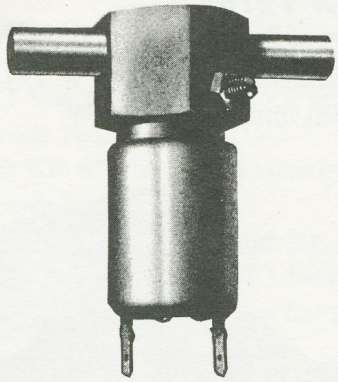
With the car on the overrun (throttle closed), a high depression exists in air intake distributor *1*. This causes valve *2* to open. Extra air is now admitted through hoses *3* from the air filter to the air intake distributor *1*, thus providing a lean mixture during overrun conditions.

Cars with automatic transmission

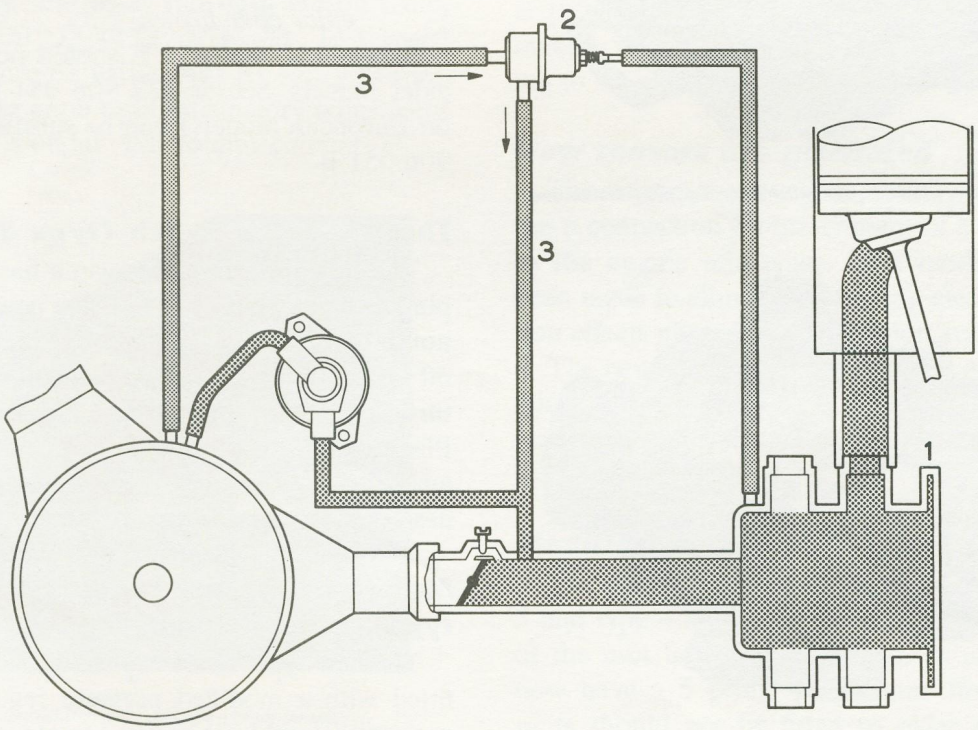
The same principle is used on cars fitted with automatic transmission, except that an electro-magnetic valve is used instead of the pneumatic valve. The valve is activated by an oil pressure switch in the automatic transmission.



Pneumatic valve (manual shift models)



Electro-magnetic valve (autom. transm. models)



Special system providing extra intake air on overrun

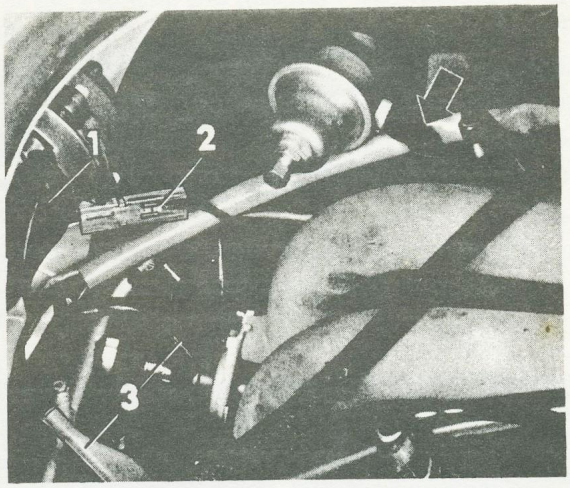
1. air intake distr.
2. valve (pneumatic for manual shift models)
3. hose connections

ERRATIC IDLING (TYPE 4 MODELS)

Erratic idling on some type 4 models, similar to that caused by a faulty ignition distributor, is sometimes caused by intruding inductive effects of the high tension ignition system.

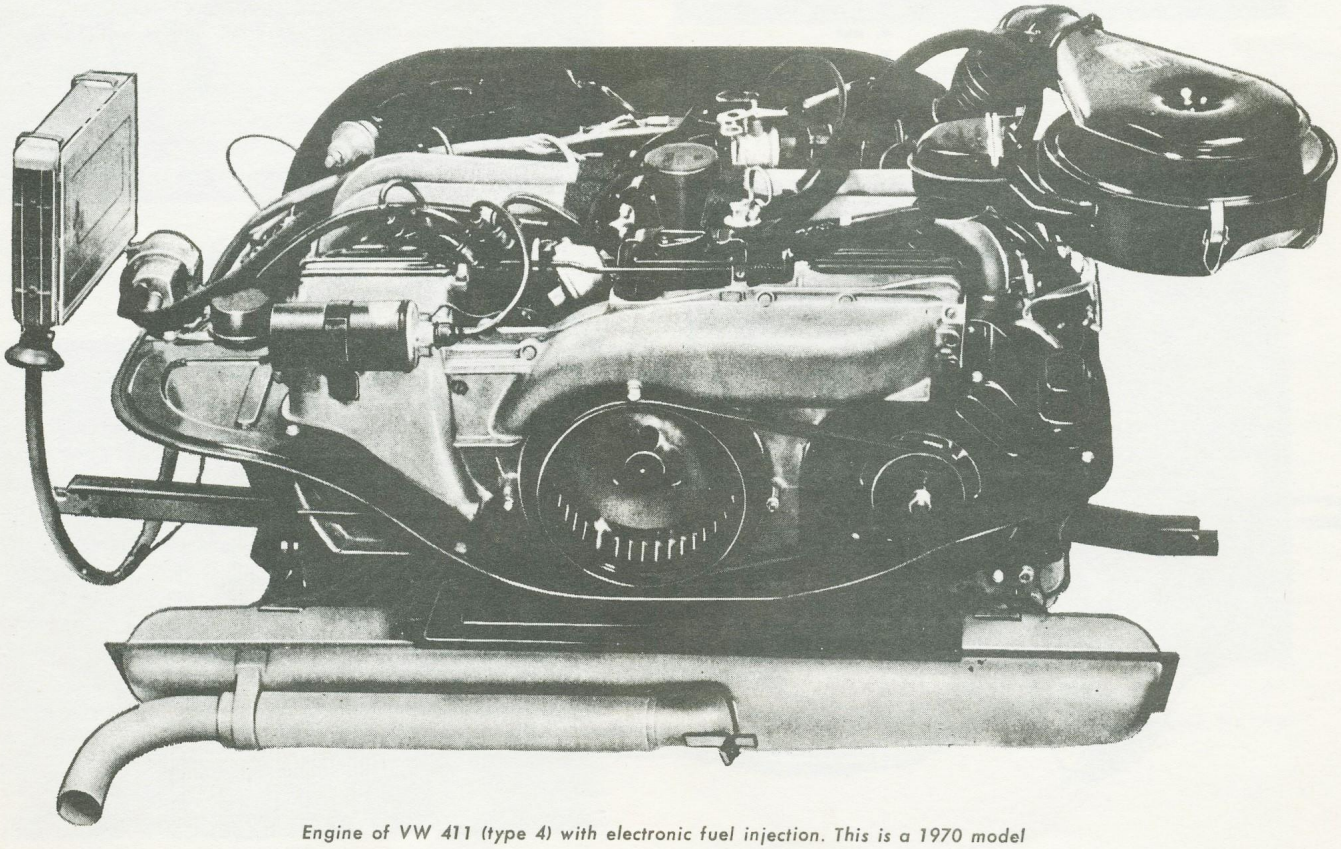
If such should be the case, a remedy can be effected by changing the part of the wiring harness connected to the pressure sensor, temp. sensor II (cyl. head) and injectors 3 and 4 in such a way that it cannot come into contact with the spark plug wire of No. 3 cylinder.

Proceed as follows (see ill.): pull off wire connections to pressure sensor, temp. sensor II (cyl. head) and injectors 3 and 4. Reroute the wire harness behind the fuel line at the pressure regulator (arrow). Reconnect the wires that have been pulled off.

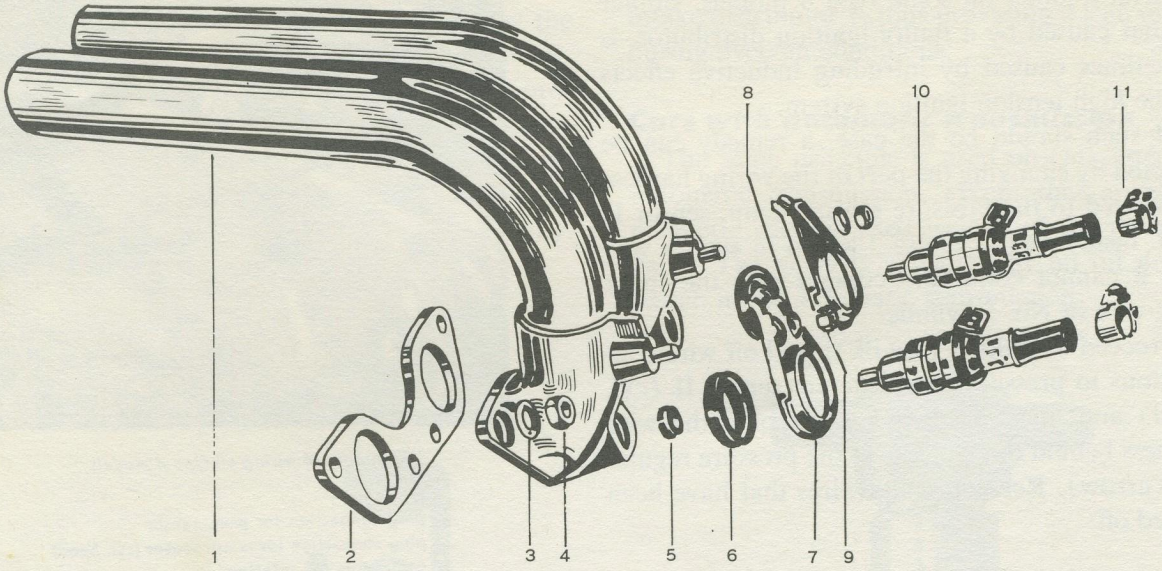


Rerouting of wiring on type 4 models

1. plug connection for pres. sensor
2. plug connection for temp. sensor (cyl. head)
3. connectors for injectors

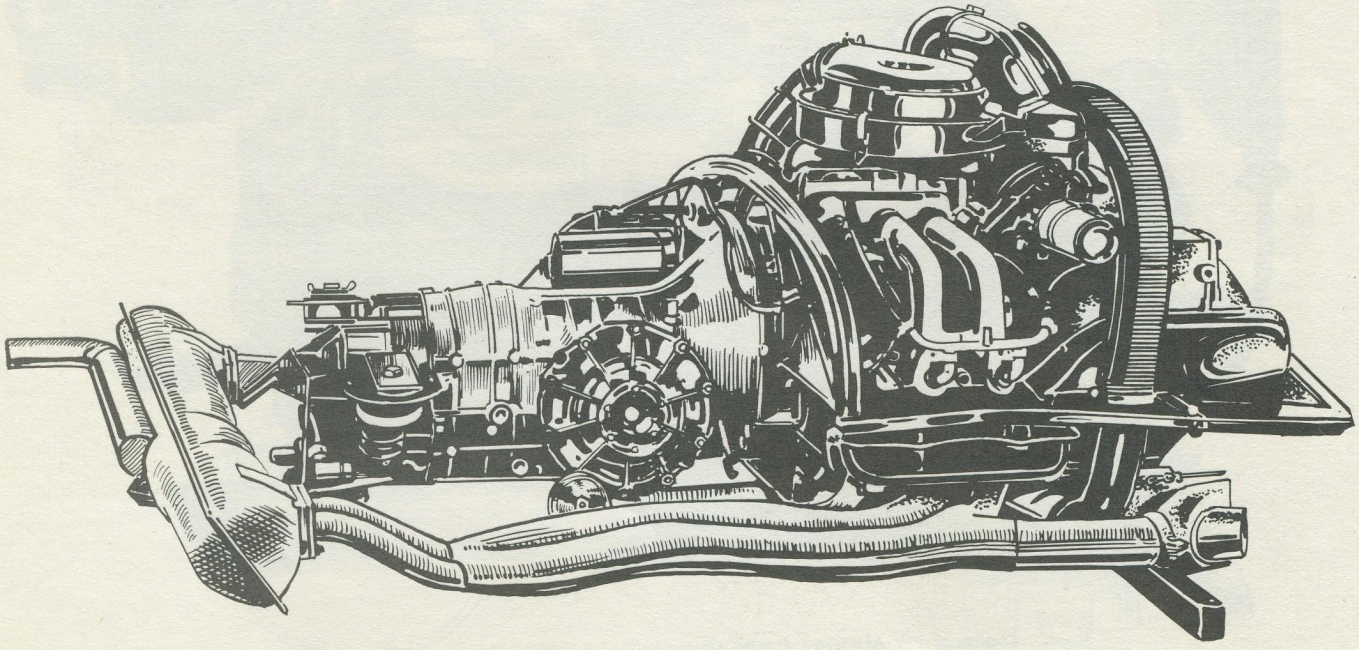


Engine of VW 411 (type 4) with electronic fuel injection. This is a 1970 model



Exploded view of injector assembly on type 4 engines

1. manifold
2. gasket
3. spring washer
4. nut
5. rubber bushing (inner)
6. rubber bushing (outer)
7. retainer plate
8. spring washer
9. nut
10. fuel injector
11. hose clamp

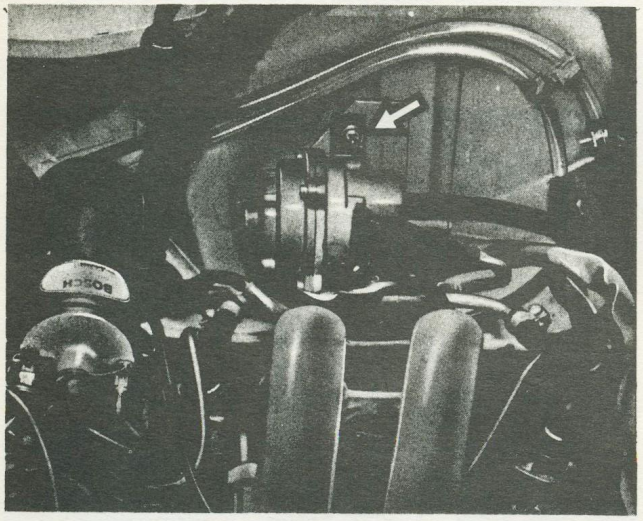


Engine and transmission package of the inboard engined Porsche 914. The engine is positioned inboard longitudinally of the rear axle center line

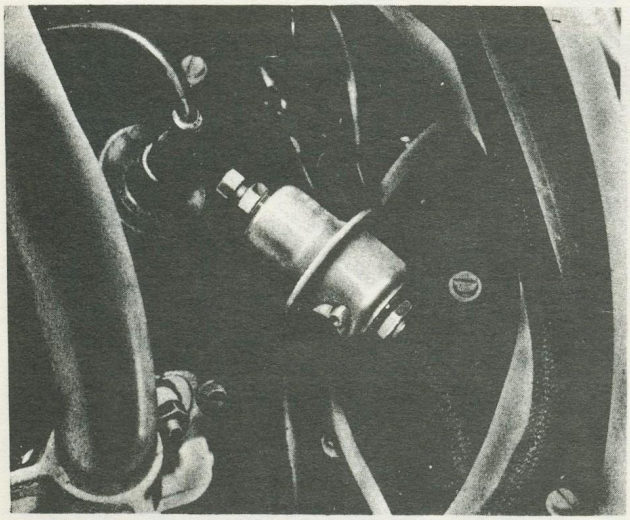
PORSCHE 914 WITH INBOARD REAR ENGINE

The Porsche 914/4 is powered with a VW 411 engine. The engine and transmission package is situated in the rear of the car, but as compared with the regular VW types, the package is turned around so that the engine is inboard longitudinally of the rear axle center line.

Due to the inboard engine position, the cylinder positions are transposed from those of the regular VW models with outboard engines. On the Porsche 914 the fuel pressure gauge connection is on the right side between No. 3 and 4 cylinders.



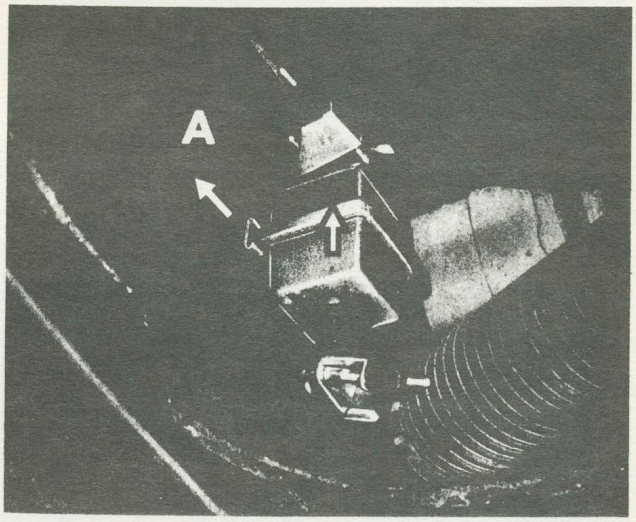
Position of pressure sensor in Porsche 914. Arrow points to top retaining screw. Two screws are below



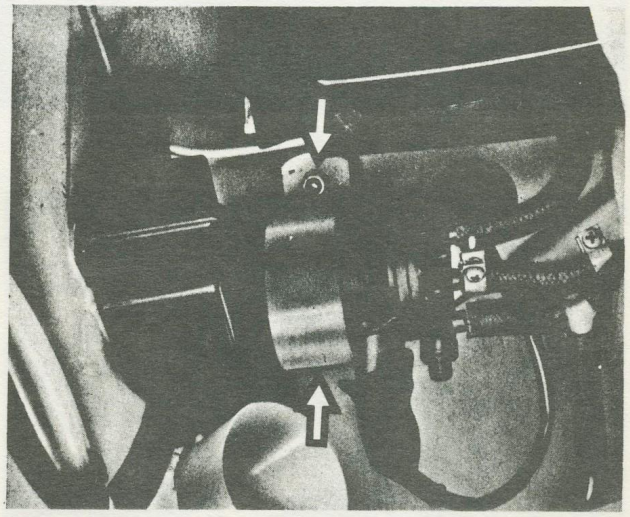
Pressure regulator is fitted to bracket to the left of No. 1 spark plug

On the Porsche the fuel filter and fuel pump are fitted underneath on the right hand side of the body in front of the engine. Access is possible only from below. To remove, clamp off both fuel hoses as shown. Disconnect hoses and take out filter in direction of arrow A. Replace filter every 20,000 km (12,000 miles).

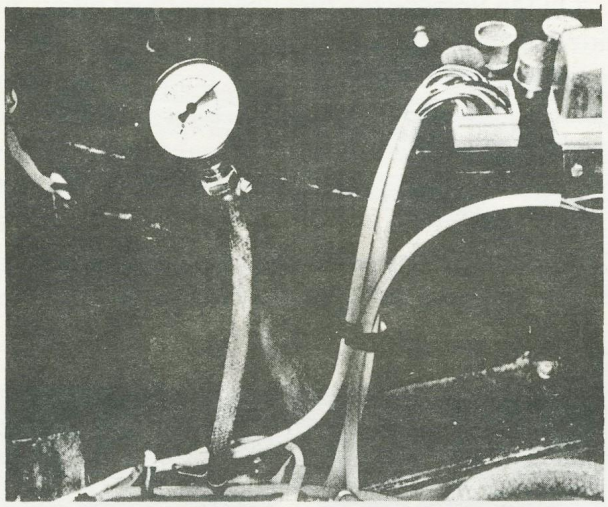
When installing, note direction of fuel flow as indicated by the arrow on the filter body.



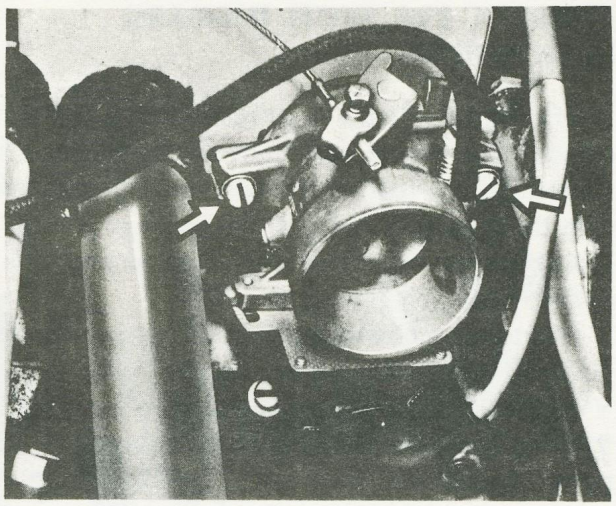
Fuel hoses should be clamped off close to the filter element.



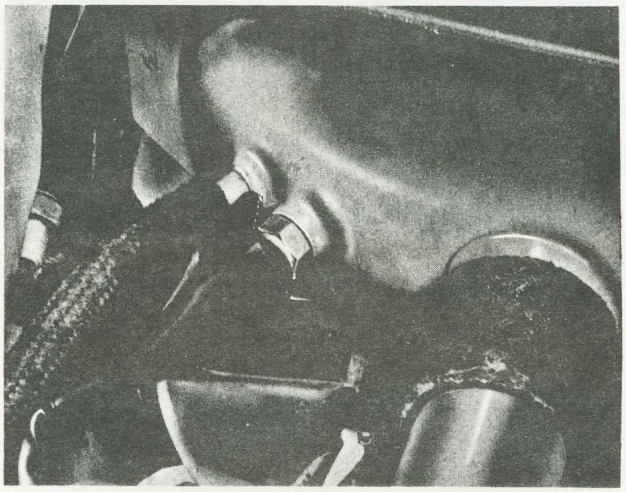
Fuel pump position on Porsche 914. Arrows indicate the two 10 mm retaining nuts



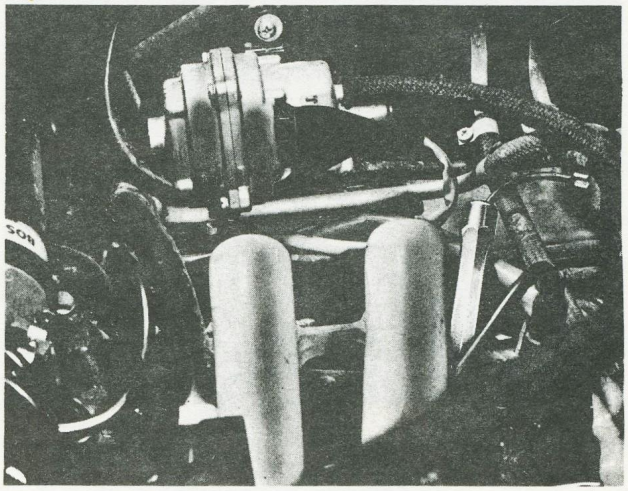
Connecting fuel pressure gauge to hose connection between No. 1 and No. 2 cylinders



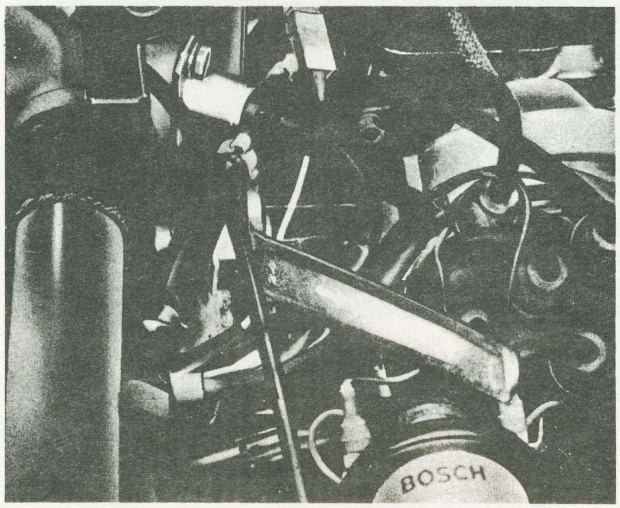
Arrows indicate retaining screws of throttle valve housing



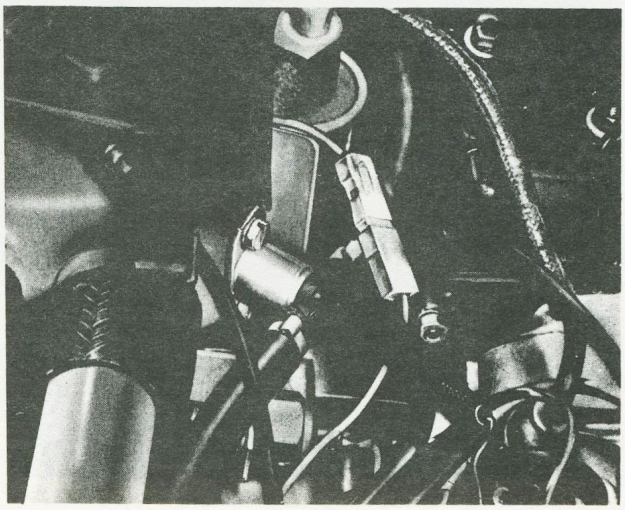
Temperature sensor in the intake air distributor



Temperature sensor in cyl. head is removed with 13 mm socket wrench



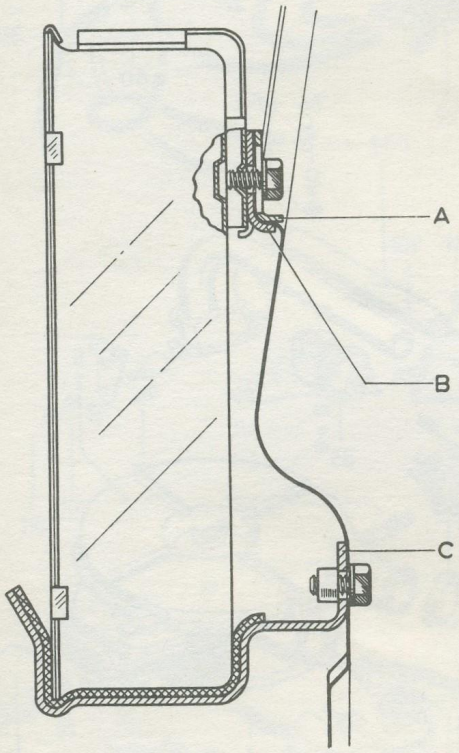
Temp. Switch is fitted to a bracket below the cold start valve. Use 24 mm open end wrench to remove as shown



Cold start valve is fitted to the rear of the air intake distributor

Installing control unit (type 4)

When installing control unit be sure that the inside and outside retaining clips are positioned as shown.

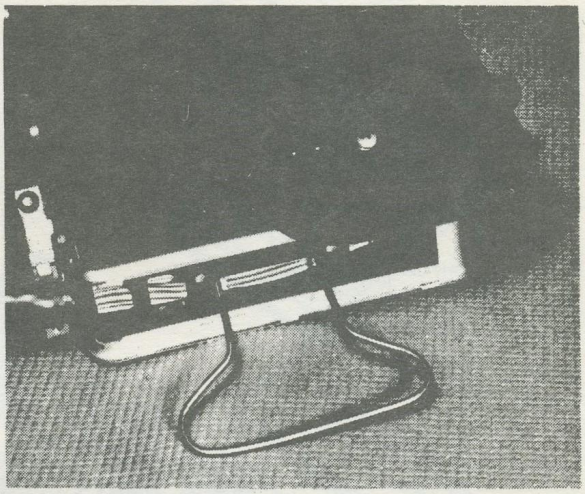


Mounting of control unit (type 4 models)

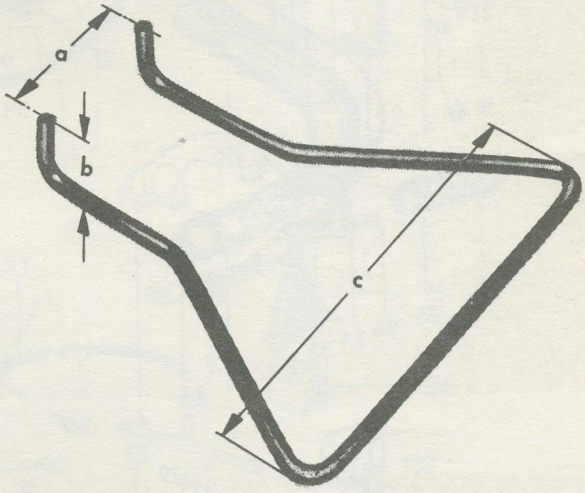
A. retaining clip (outside)
B. spring clip (inside)
C. carrier for unit

Hose cutter pliers

A simple extractor tool as shown is convenient for extracting the multiple plug of the cable harness. The extractor tool is made out of welding wire 2 mm thick (about 5/64 in.) and should be shaped as shown in the illustration.

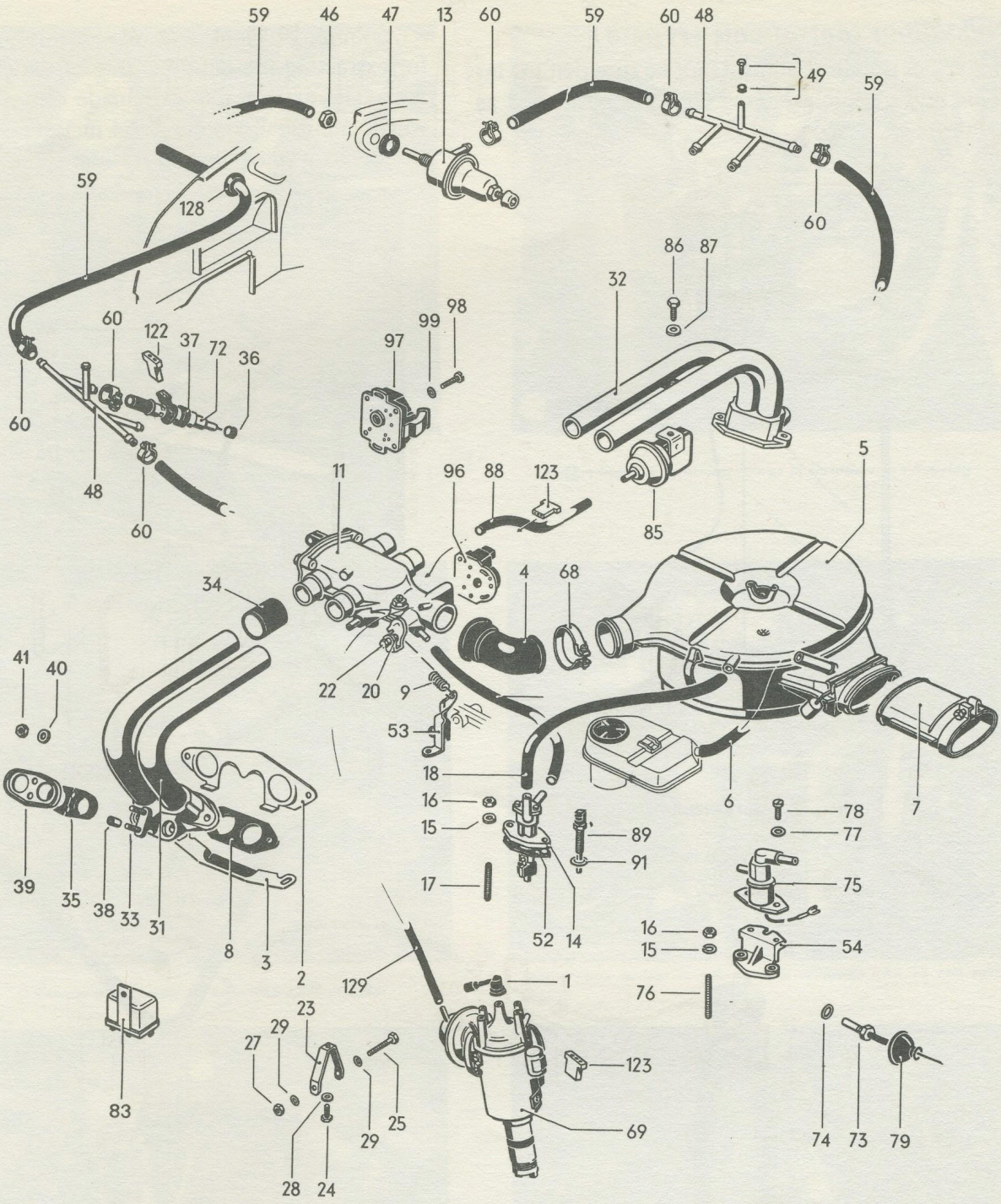


Extracting cable harness plug with special extractor



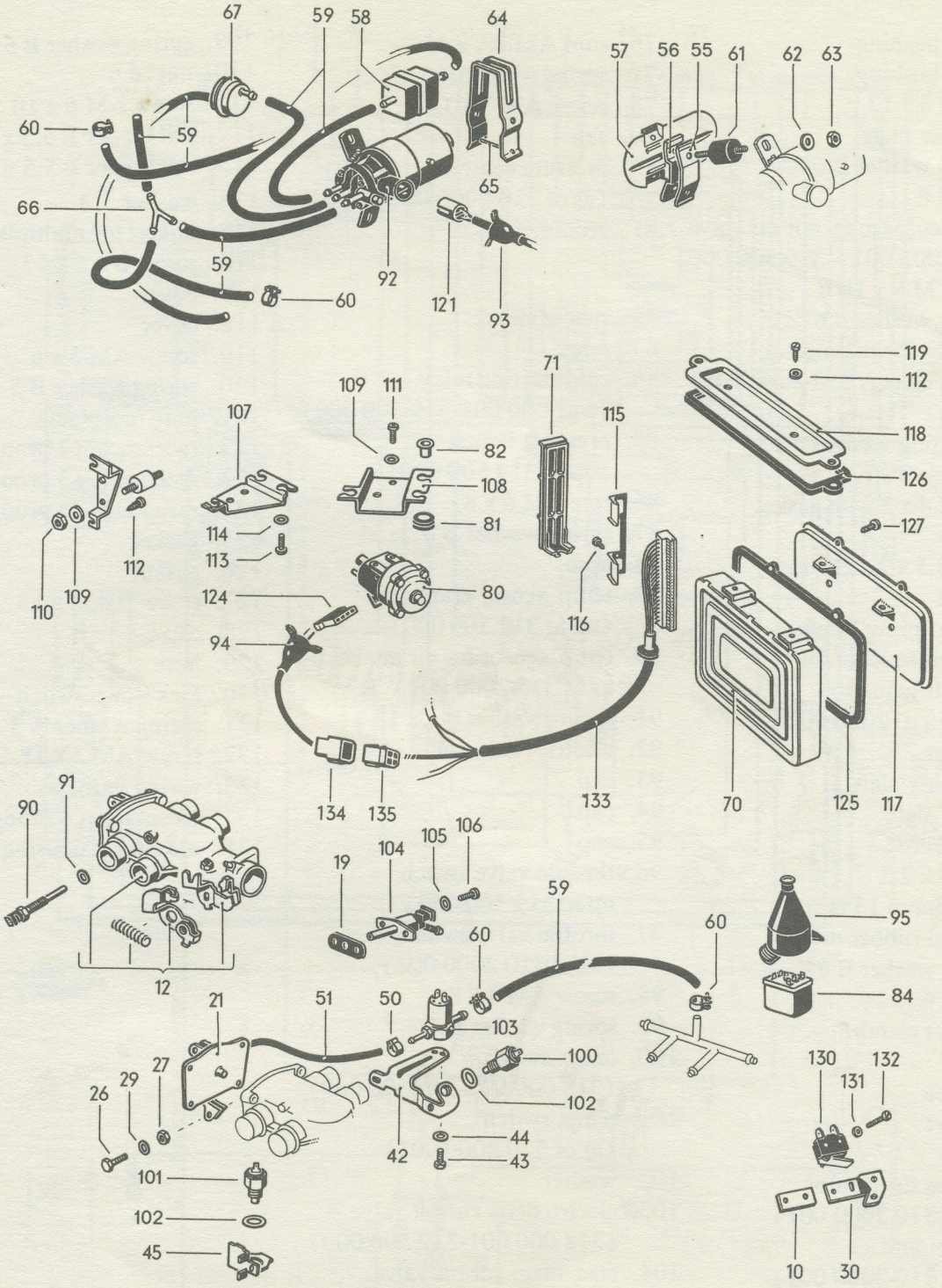
a. 45 mm
b. 12 mm
c. 100 mm

Hose clamp



Components of the fuel injection system on late type 3 model

1. high tension cable plug
2. cover plate (inner)
3. cover plate (outer)
4. elbow piece
5. air filter
6. hose 12 x 3.3
7. connecting piece
8. gasket
9. return spring
10. plate for kickdown switch
11. intake air distr. assy. (as of chassis 310 2000 001)
12. intake air distr. assy. autom. (as of chassis 310 2000 001)
13. pressure switch
14. aux. air regulator chassis 318 000 001-319 500 000)
15. spring washer B 8 x 15
16. nut M 8
17. stud AM 8A x 31
18. hose



Components of the fuel injection system type 3 models (as of Aug '69)

19. gasket
20. pin for throttle cable
21. cover with cold start jet (318 000 001-319 500 000)
22. screw M 5 x 10
23. support bracket
24. screw M 6 x 15
25. screw BM 8 x 60
26. screw M8 x 25
27. nut M 8
28. spring washer B 6
29. spring washer A 8
30. support for kick down switch
31. manifold (left)
32. manifold (right)
33. stud AM 6A x 28
34. hose 31 x 4 x 45
35. retainer plate

36. inner bushing
37. outer bushing
38. sleeve 8 x 12
39. retainer plate
40. spring washer B 6
41. nut M 6
42. bracket for mag. cut-off valve (318 000 001 – 319 500 000)
43. screw M 6 x 10 K
44. spring washer B 6
45. bracket for thermostat (as of chassis 310 2000 001)
46. nut
47. insulating washer
48. fuel line distr.
49. nut M 4 x 8 with gasket
50. clamp
51. hose 3.5 x 2 (210 mm)
52. gasket
53. return spring bracket
54. support bracket for aux. air regulator (as of 310 2000 001)
55. bracket
56. clamping plate
57. shield plate
58. fuel filter
59. hose 7 x 2.5
60. hose clamp 13 mm
61. bonded rubber mount
62. spring washer B 6
63. nut M 6
64. support clamp
65. pin
66. Y-piece
67. damper
68. clamp
69. ignition distributor (as of 310 2000 001)
70. control unit (as of 310 2000 001)
71. end cover
72. injector
73. temp. sensor (cyl. head)
74. spring washer A 10
75. aux. air regulator (as of 310 2000 001)
76. stud AM 8A x 35
77. spring washer B 5
78. screw AM 5 x 12
79. cap
80. pressure sensor (as of 310 2000 001)
81. grommet
82. spacer sleeve
83. relay
84. cold starting relay (318 000 001-319 500 000)
85. pressure switch (up to 319 500 000)
86. screw M 6 x 8
87. spring washer B 6
88. hose
89. temp. sensor crankcase (up to 319 500 000)
90. temp. sensor for air intake distr. as of 310 2000 001)
91. spring washer B 8 x 15
92. electric fuel pump
93. cap
94. cap
95. cap
96. throttle valve switch up to 319 500 000)
97. throttle valve switch (as of 310 2000 001)
98. screw AM 4 x 8
99. spring washer B 4
100. temp. switch (318 000 001-319 500 000)
101. temp. switch (as of 310 2000 001)
102. washer
103. electro mag. cut-off valve (318 000 001-319 500 000)
104. elec. mag. cut-off valve (as of 310 2000 001)
105. washer A 6
106. screw AM 6 x 10
107. bracket for pressure sensor
108. bracket for pressure sensor (as of 310 2000 001)
109. spring washer B 6
110. nut M 6
111. screw AM 6 x 10
112. self tapper B 5.5 x 19
113. self tapper B 5.5 x 25
114. washer 5, 1
115. holder for multiple prong plug
116. screw B 3.5 x 13
117. cover
118. cover
119. screw AM 5 x 6
120. spring washer B 5
121. plug receptacle
122. receptacle (2 prong)
123. receptacle (3 prong)
124. receptacle (4 prong)
125. gasket
126. gasket
127. screw B 4, 8 x 13
128. cap
129. hose
130. kick down switch
131. spring washer A 3
132. screw AM 3 x 18
133. wiring harness
134. receptacle (4 prong)
135. receptacle housing

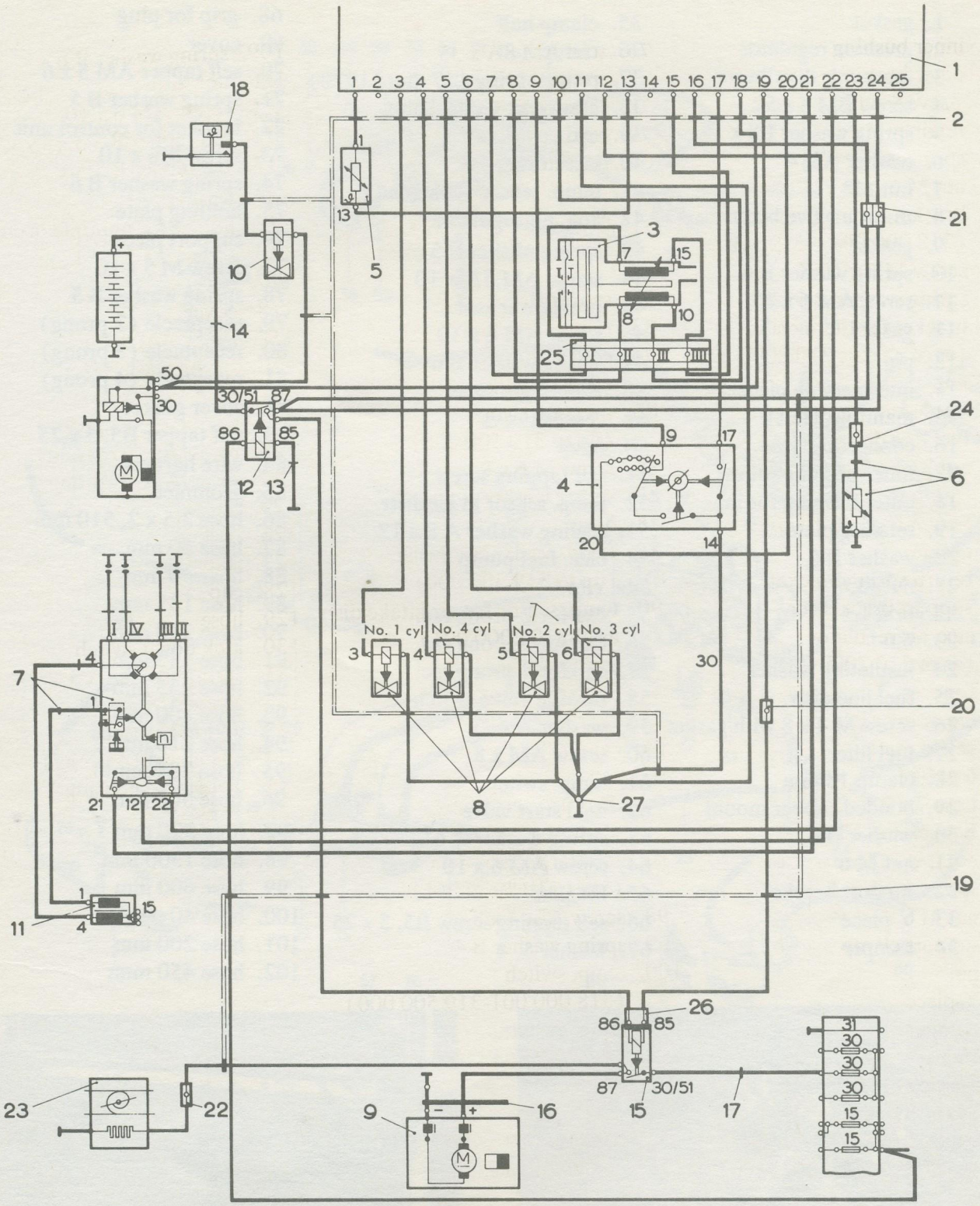
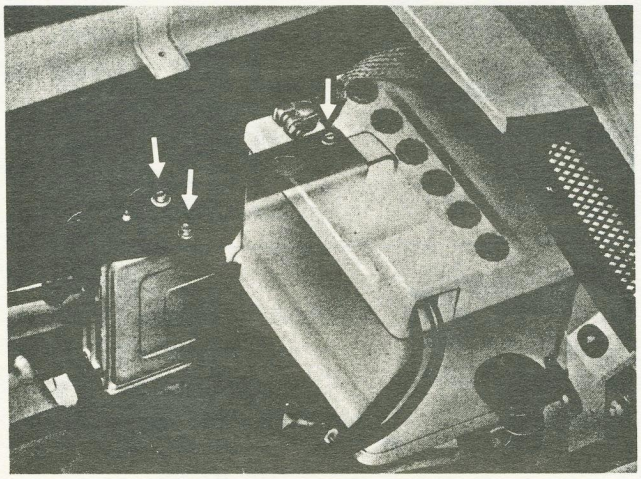


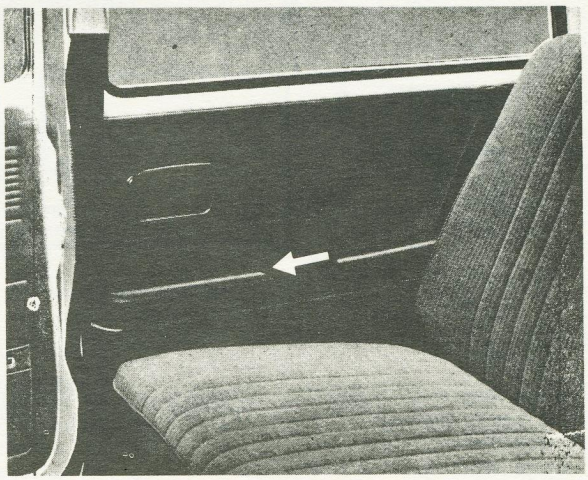
Diagram of electrical part of late type 3 fuel injection system

1. control unit
2. wire conn. control unit
3. pressure sensor
4. throttle valve and power enrichment switch
5. temp. sensor in air intake distr.
6. temp. sensor (cyl. head)
7. ign. distr. with trigger contacts
8. fuel injectors
9. electric fuel pump
10. cold start valve
11. ignition coil
12. voltage supply relay
13. wire for voltage supply relay
14. wire from battery to relay
15. pump relay
16. wire conn. fuel pump
17. wire conn. between fuse box and pump relay
18. thermo switch (cold starting)
19. main wire loom
20, 22, 24. wire connectors (single)
21. wire connector (double)
23. aux. air regulator
25. 4 prong connector
26. receptacle for pump relay
27. ground connection on engine crankcase

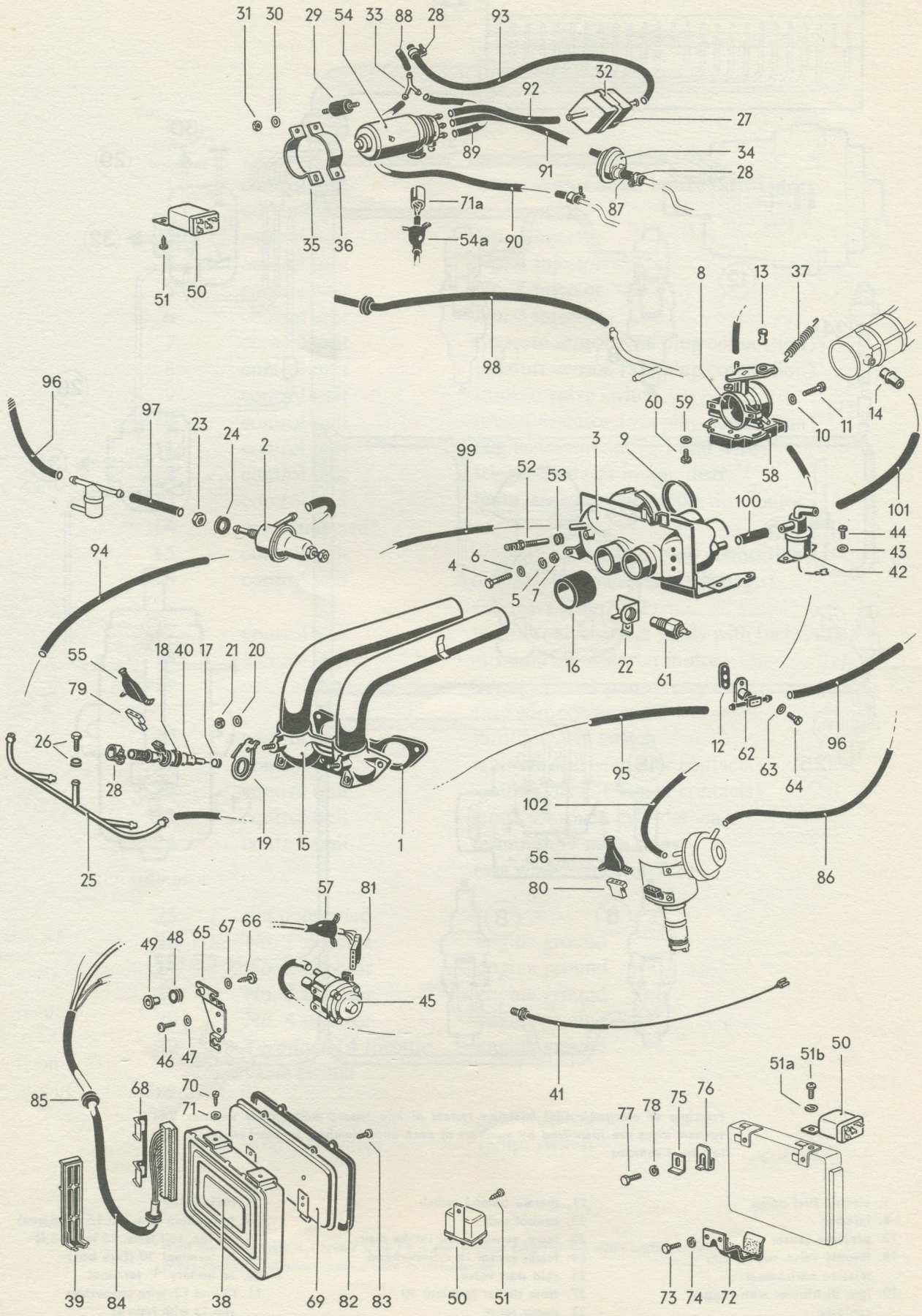
1. gasket
2. pressure regulator
3. intake air distributor
4. screw BM 8 x 52
5. spring washer B8 x 15
6. washer A8, 4
7. nut M8
8. throttle valve body
9. gasket
10. spring washer B 6
11. screw AM 6 x 25
12. gasket
13. pin
14. intermediate piece
15. manifold (left)
16. connecting hose
17. inner bushing for inj.
18. outer bushing for inj.
19. retainer plate
20. washer B 6
21. nut M 6
22. bracket
23. nut
24. insulating washer
25. fuel line distr.
26. screw M 4 x 8 with gasket
27. fuel filter
28. clamp 13 mm
29. bonded rubber mount
30. washer B 6
31. nut M 6
32. support bracket
33. Y-piece
34. damper
35. clamp half
36. clamp half
37. return spring 147 mm (1970)
38. electronic control unit
39. end cover
40. injector
41. temp. sensor (cyl. head)
42. aux. air regulator
43. spring washer B 5
44. screw AM 5A x 10
45. pressure sensor
46. screw AM 6 x 10
47. spring washer B 6
48. rubber grommet
49. spacer sleeve
50. relay
51. self tapping screw
52. temp. sensor in air distr.
53. sealing washer A 8 x 12
54. elec. fuel pump
54a. cap
55. cap for 2-prong rec.
56. cap for 3-prong rec.
57. cap for 4-prong rec.
58. throttle valve switch
59. washer A 4, 3
60. screw AM x 8
61. temp. switch
62. cold start valve
63. spring washer A 6
64. screw AM 6 x 10
65. bracket
66. self tapping screw B5, 5 x 25
67. washer 5, 1
68. grip for plug
69. cover
70. self tapper AM 5 x 6
71. spring washer B 5
72. bracket for control unit
73. screw M6 x 10
74. spring washer B 6
75. holding plate
76. support piece
77. screw M 5 x 10
78. spring washer B 5
79. receptacle (2 prong)
80. receptacle (3 prong)
81. receptacle (4 prong)
82. cover gasket
83. self tapper B5, 5 x 25
84. wire harness
85. grommet
86. hose 3.5 x 2, 510 mm
87. hose 50 mm
88. hose 50 mm
89. hose 135 mm
90. hose 210 mm
91. hose 185 mm
92. hose 235 mm
93. hose 400 mm
94. hose 210 mm
95. hose 385 mm
96. hose 500 mm
97. hose 570 mm
98. hose 1300 mm
99. hose 600 mm
100. hose 40 mm
101. hose 200 mm
102. hose 450 mm



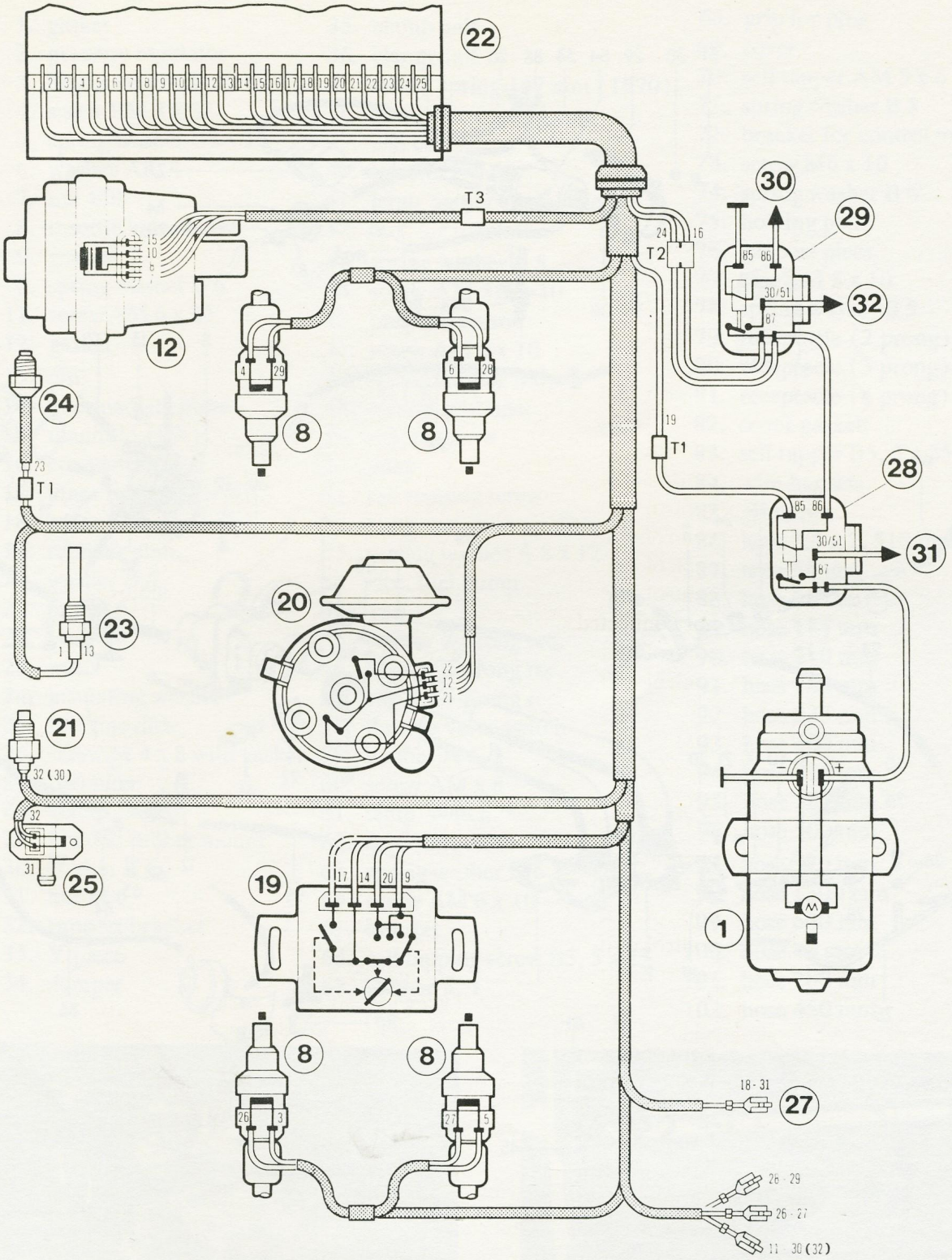
Electronic control unit is fitted next to battery in Porsche 914 model



In the VW 411 Variant the electronic control unit is situated on the right side next to the rear seat



Components of the fuel injection system type 4 engines. *Legend is shown on opposite page*



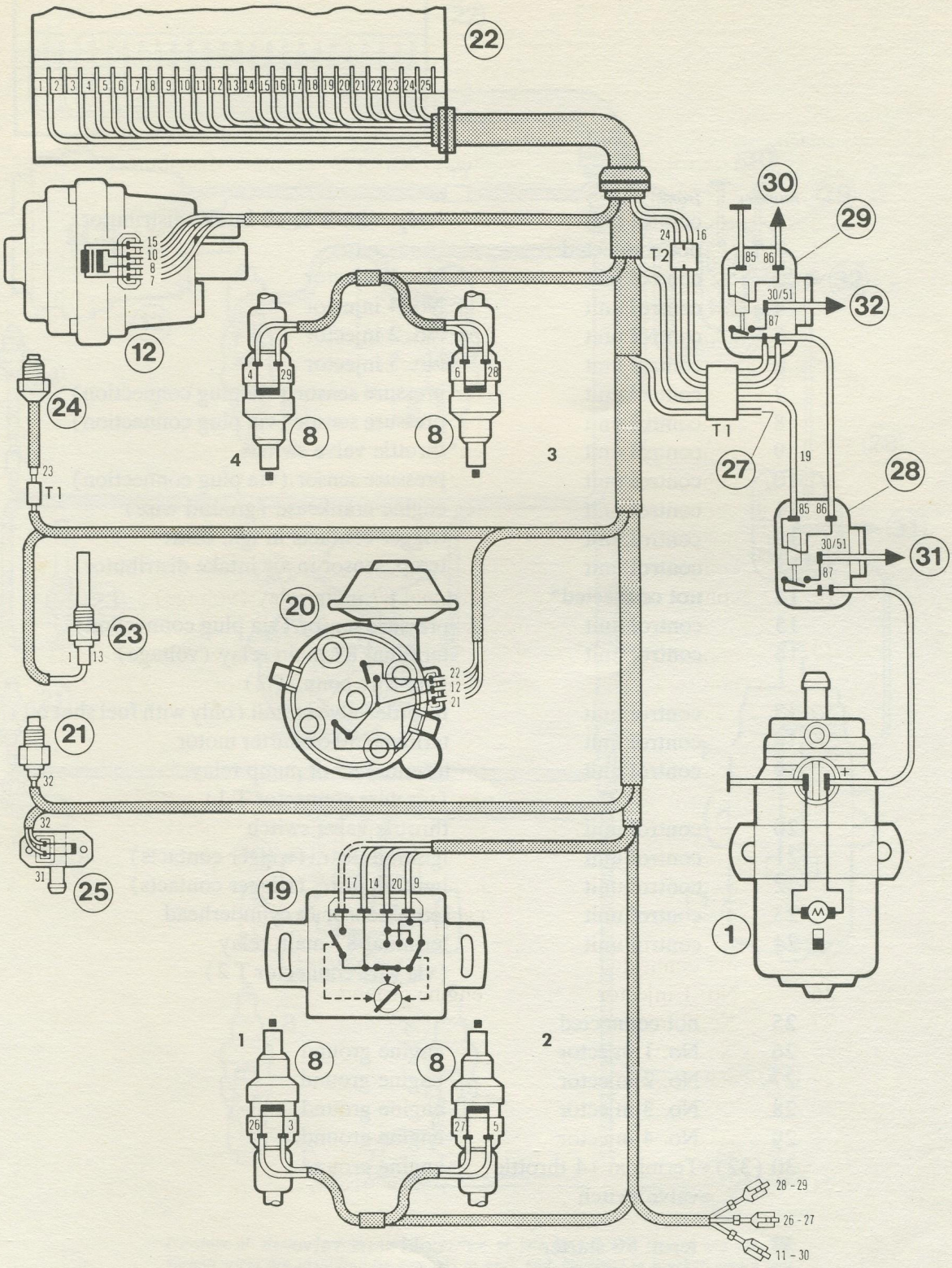
Principle of electronic fuel injection system of late type 3 and type 4 engines. The various wires are identified by numbers at each end. Numbers in brackets apply only to type 4 vehicles

1. electric fuel pump
8. injector
12. pressure sensor
19. throttle valve switch with mixture enrichment
20. ign. distributor with trigger contacts
21. thermo (temp.) switch
22. control unit
23. temp. sensor in air intake distr.
24. temp. sensor in cylinderhead
25. cold start valve
27. from starter terminal 50
28. pump relay
29. main relay
30. to ignition terminal 15 (fuse box) (to ign. coil term. 15 in type 4)
31. to terminal 30 (fuse box)
32. to battery + terminal

T1, T2 and T3: wire connectors (no T3 with type 4)

Wire number	*from*	*to*
1	control unit	temp. sensor in air intake distributor
2	not connected	
3	control unit	No. 1 injector
4	control unit	No. 4 injector
5	control unit	No. 2 injector
6	control unit	No. 3 injector
7	control unit	pressure sensor (via plug connection)
8	control unit	pressure sensor (via plug connection)
9	control unit	throttle valve switch
10	control unit	pressure sensor (via plug connection)
11	control unit	engine crankcase (ground wire)
12	control unit	trigger contacts in ign. distr.
13	control unit	temp. sensor in air intake distributor
14	not connected*	
15	control unit	pressure sensor (via plug connection)
16	control unit	terminal 87 main relay (voltage) (via wire conn. T 2)
17	control unit	throttle valve switch (only with fuel shut off)
18	control unit	terminal 50 of starter motor
19	control unit	terminal 85 of pump relay (via wire connector T 1)
20	control unit	throttle valve switch
21	control unit	ignition distr. (trigger contacts)
22	control unit	ignition distr. (trigger contacts)
23	control unit	temp. sensor in cylinderhead
24	control unit	terminal 87 main relay (via wire connector T 2)
25	not connected	
26	No. 1 injector	engine ground
27	No. 2 injector	engine ground
28	No. 3 injector	engine ground
29	No. 4 injector	engine ground
30 (32)	Terminal 14 throttle valve switch	engine ground
31	term. 50 starter	cold start valve
32 (30)	cold start valve	temp. switch

**With the early type 4 Variant wire 14 is the ground wire for the main (voltage) relay When checking, connect ground wire to terminal 85*



Principle of electronic fuel injection system of the Porsche 914/4 powered with inboard VW 411 engine. The various wires are identified by numbers at each end

1. electric fuel pump
8. injector
12. pressure sensor
19. throttle valve switch with mixture enrichment
20. ign. distributor with trigger contacts
21. thermo (temp.) switch
22. control unit
23. temp. sensor in air intake distr.
24. temp. sensor in cylinderhead
25. cold start valve
27. wire 18 and 31 from term. 50
28. pump relay
29. main relay
30. to ignition terminal 15 (fuse box)
31. to terminal 30 (fuse box)
32. to battery + terminal

T1 wire plug connection
T2 wire connector

Wire number	*from*	*to*
1	control unit	temp. sensor in air intake distributor
2	not connected	
3	control unit	No. 1 injector
4	control unit	No. 4 injector
5	control unit	No. 2 injector
6	control unit	No. 3 injector
7	control unit	pressure sensor
8	control unit	pressure sensor
9	control unit	throttle valve switch
10	control unit	pressure sensor
11	control unit	engine crankcase (ground wire)
12	control unit	trigger contacts in ign. distr.
13	control unit	temp. sensor in air intake distributor
14	not connected	
15	control unit	pressure sensor
16	control unit	terminal 87 main relay (voltage) (via wire conn. T 1)
17	control unit	throttle valve switch (only with fuel shut off)
18	control unit	terminal 50 of starter motor
19	control unit	terminal 85 of pump relay (via wire connector T 1)
20	control unit	throttle valve switch
21	control unit	ignition distr. (trigger contacts)
22	control unit	ignition distr. (trigger contacts)
23	control unit	temp. sensor in cylinderhead
24	control unit	terminal 87 main relay (via wire connector T 1)
25	not connected	
26	No. 1 injector	engine ground
27	No. 2 injector	engine ground
28	No. 3 injector	engine ground
29	No. 4 injector	engine ground
30	Terminal 14 throttle valve switch	engine ground
31	term. 50 starter	cold start valve (via wire connector T 1)
32	cold start valve	temp. switch

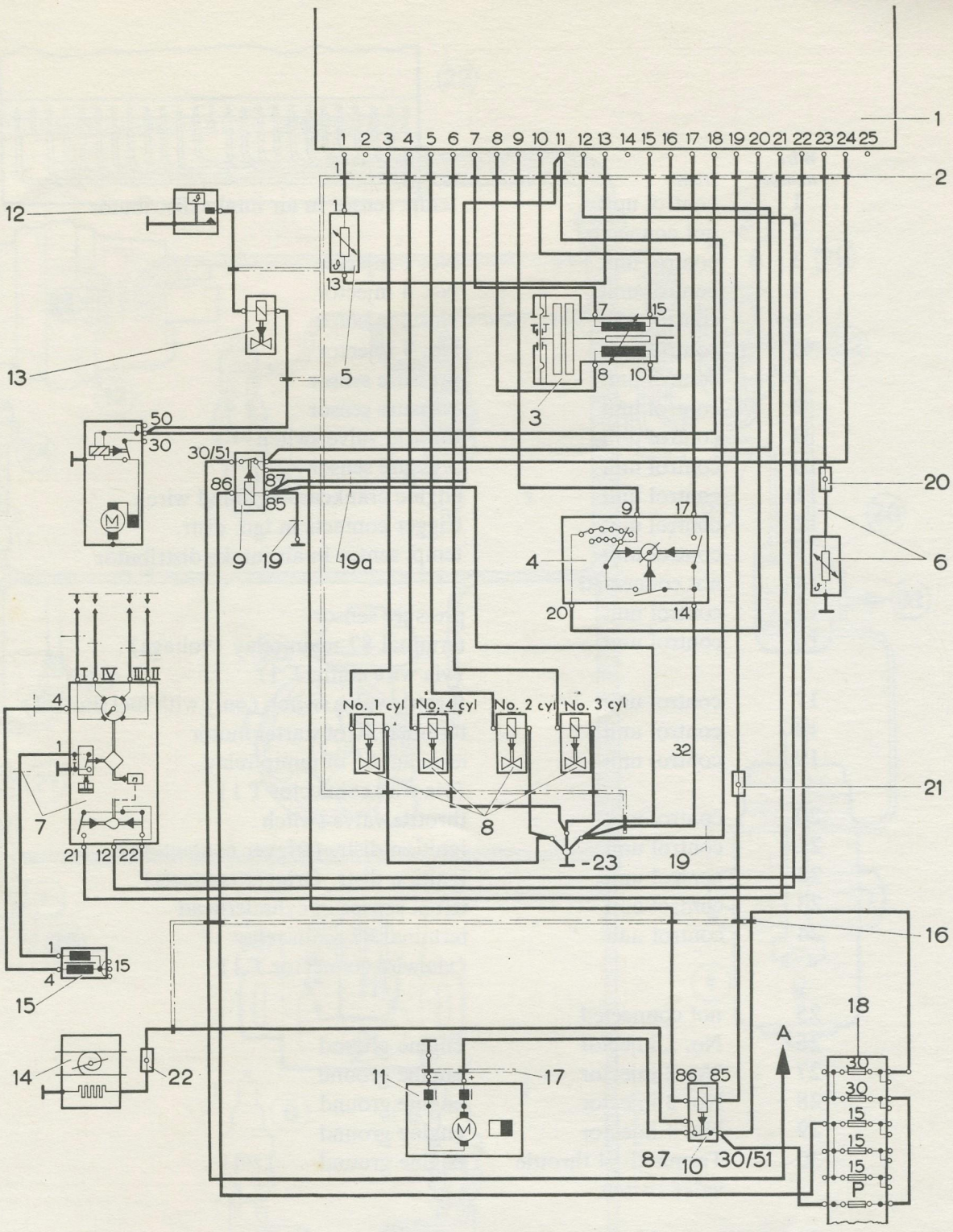


Diagram of electrical part of fuel injection system, (type 4 models)

1. control unit
2. wire harness control unit
3. pressure sensor
4. throttle valve switch and power enrichment switch
5. temp. sensor in air int. distr.
6. temp. sensor (cyl. head)
7. ign. distr. with trigger contacts
8. fuel injectors
9. voltage relay
10. pump relay
11. electric fuel pump
12. temp. switch (cold start)
13. cold start valve
14. aux. air regulator
15. ignition coil
16. wires in cable harness
17. wire harness fuel pump
18. fuse box
19. ground wire sedan
19a. ground wire Variant
20. wire connector (single)
21. wire connector (single)
22. wire connector (single)
23. ground connection (crankcase)

A. to battery + terminal

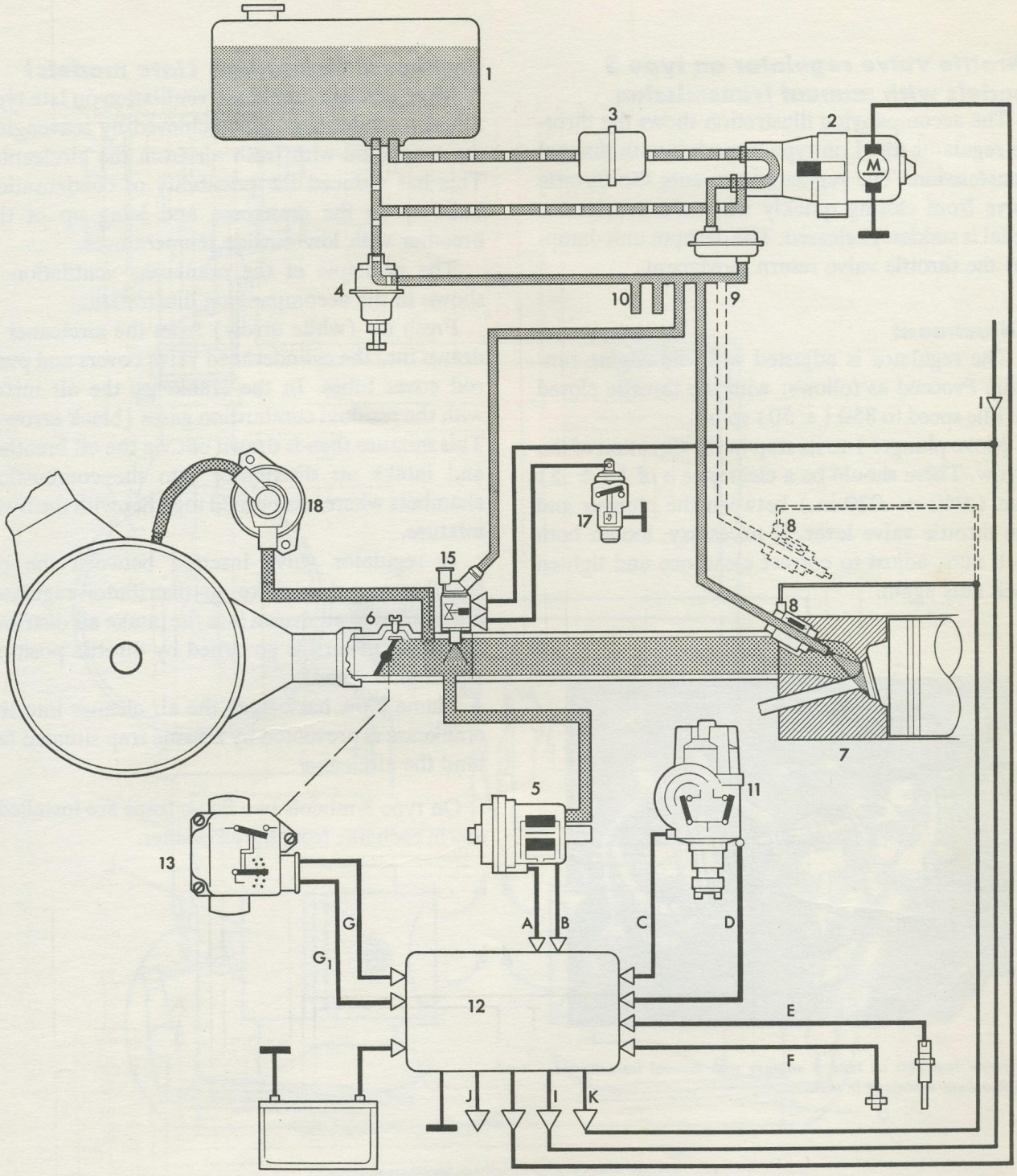


Diagram of late type fuel injection system used on type 3 and type 4 models. This system uses the latest type throttle valve switch with power mixture enrichment

1. fuel tank
2. electric fuel pump
3. fuel filter
4. fuel pressure regulator
5. pressure sensor
6. air intake distr.
7. cylinderhead
8. fuel injectors
9. fuel loop line
10. conn. for fuel line (cold starting)
11. ign. distr. with trigger contacts
12. electronic control unit
13. throttle valve switch with power mixture enrichment
15. cold starting jet
16. elec. magnetic valve (cold starting)
17. temp. switch (cold starting)
18. aux. air regulator

A and B. signals from pressure sensor
C and D. signals from trigger contacts
E and F. signals from temp. sensors (warming up phase)
G. signal from throttle valve switchi (fuel shut off on overrun)
G_1. power mixture enrichment
I. signal from starter (term 50)
J. signal to injectors 1 and 4
K. signal to injectors 2 and 3

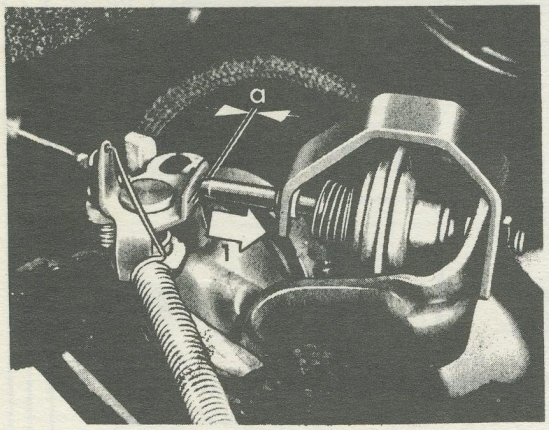
Throttle valve regulator on type 3 models with manual transmission

The accompanying illustration shows the throttle regulator fitted on type 3 models with manual transmission. The regulator prevents the throttle valve from closing quickly when the accelerator pedal is suddenly released. The dashpot unit dampens the throttle valve return movement.

Adjustment

The regulator is adjusted with the engine running. Proceed as follows: with the throttle closed set idle speed to 850 (± 50) rpm.

Move plunger 1 to its stop in the direction of the arrow. There should be a clearance *a* of 1 (± .5) mm (.040 ± .020 in.) between the plunger and the throttle valve lever. If necessary, loosen both lock nuts, adjust to correct clearance and tighten lock nuts again.



Throttle regulator on type 3 engines with manual transmission
Adjustment explained in text

Crankcase ventilation (late models)

More efficient crankcase ventilation on late type 3 and 4 models has been achieved by scavenging the crankcase with fresh air from the aircleaner. This has reduced the possibility of condensation build-up in the crankcase and icing up of the breather with low outside temperatures.

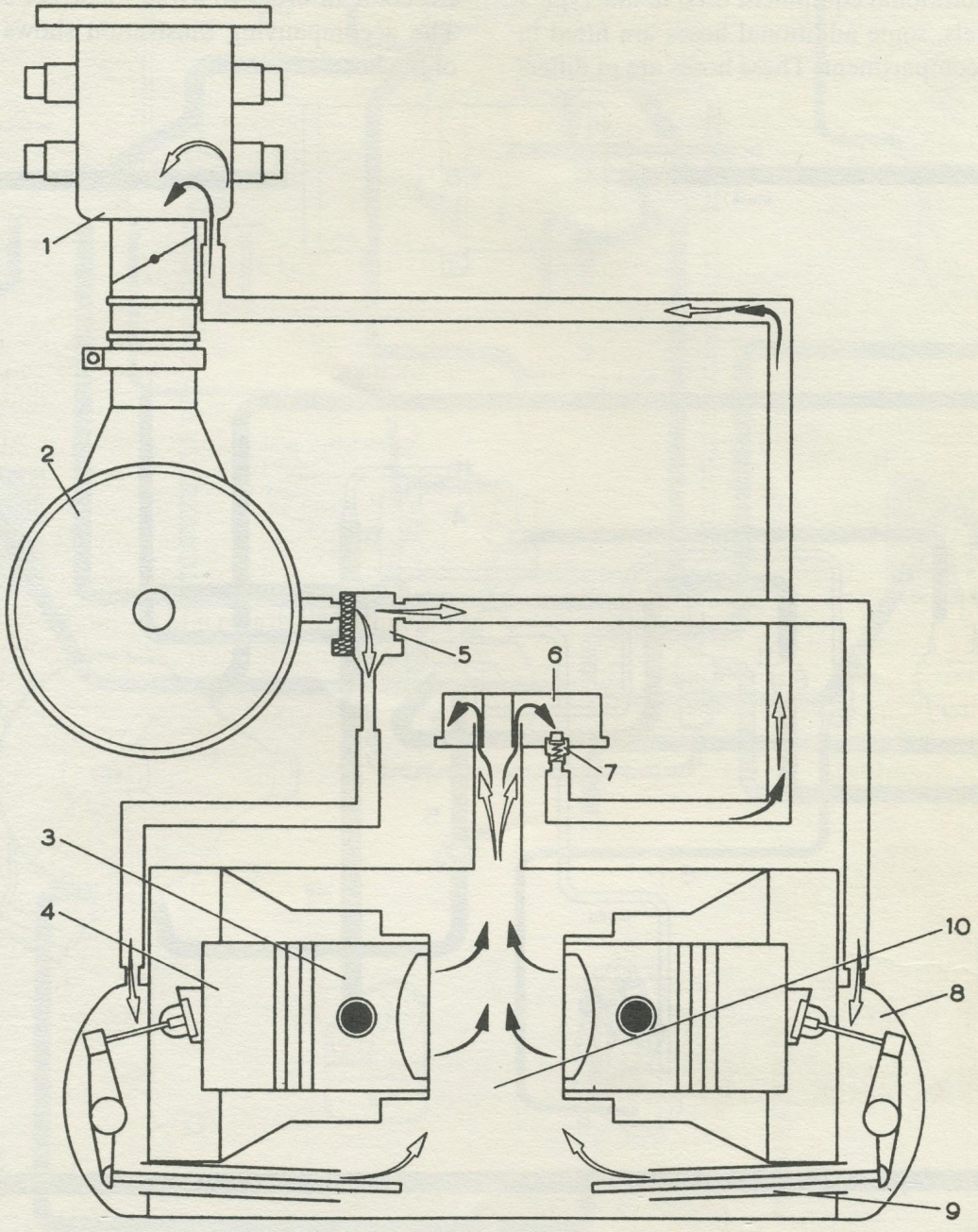
The principle of the crankcase ventilation is shown in the accompanying illustration.

Fresh air (white arrow) from the aircleaner is drawn into the cylinderhead valve covers and push rod cover tubes. In the crankcase the air mixes with the residual combustion gases (black arrow). This mixture then is drawn out via the oil breather and intake air distributor into the combustion chambers where it is burned together with the fresh mixture.

A regulator valve inserted between the oil breather and the intake air distributor regulates the amount of air drawn into the intake air distributor which in turn is governed by throttle position and engine speed.

Flame blow back from the air cleaner into the crankcase is prevented by a flame trap situated behind the aircleaner.

On type 3 models two flame traps are installed: one in each line from the aircleaner.

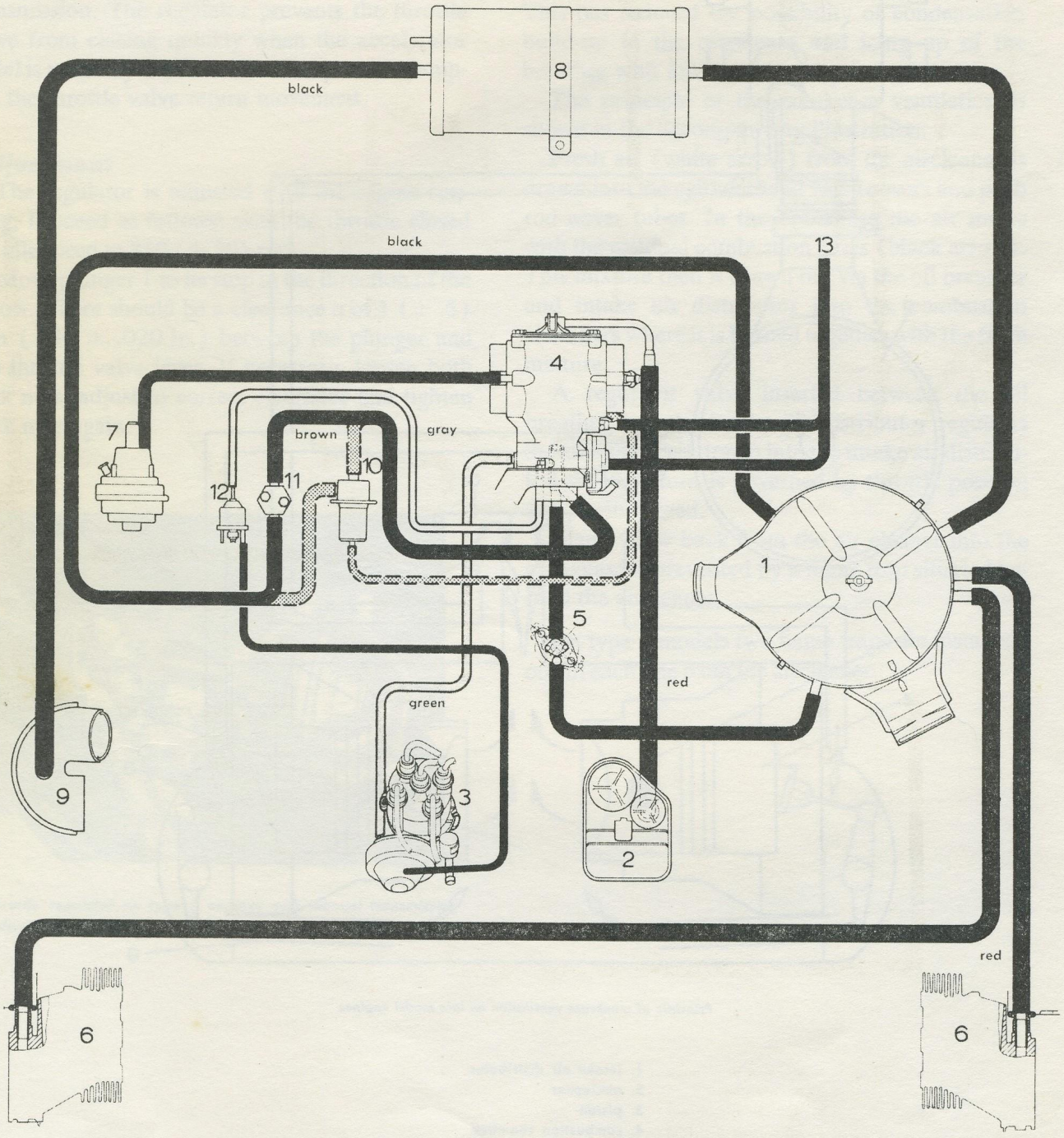


Principle of crankcase ventilation on late model engines

1. intake air distributor
2. aircleaner
3. piston
4. combustion chamber
5. junction piece with flame trap
6. oil breather
7. regulator valve
8. cyl. head cover
9. pushrod tube
10. crankcase

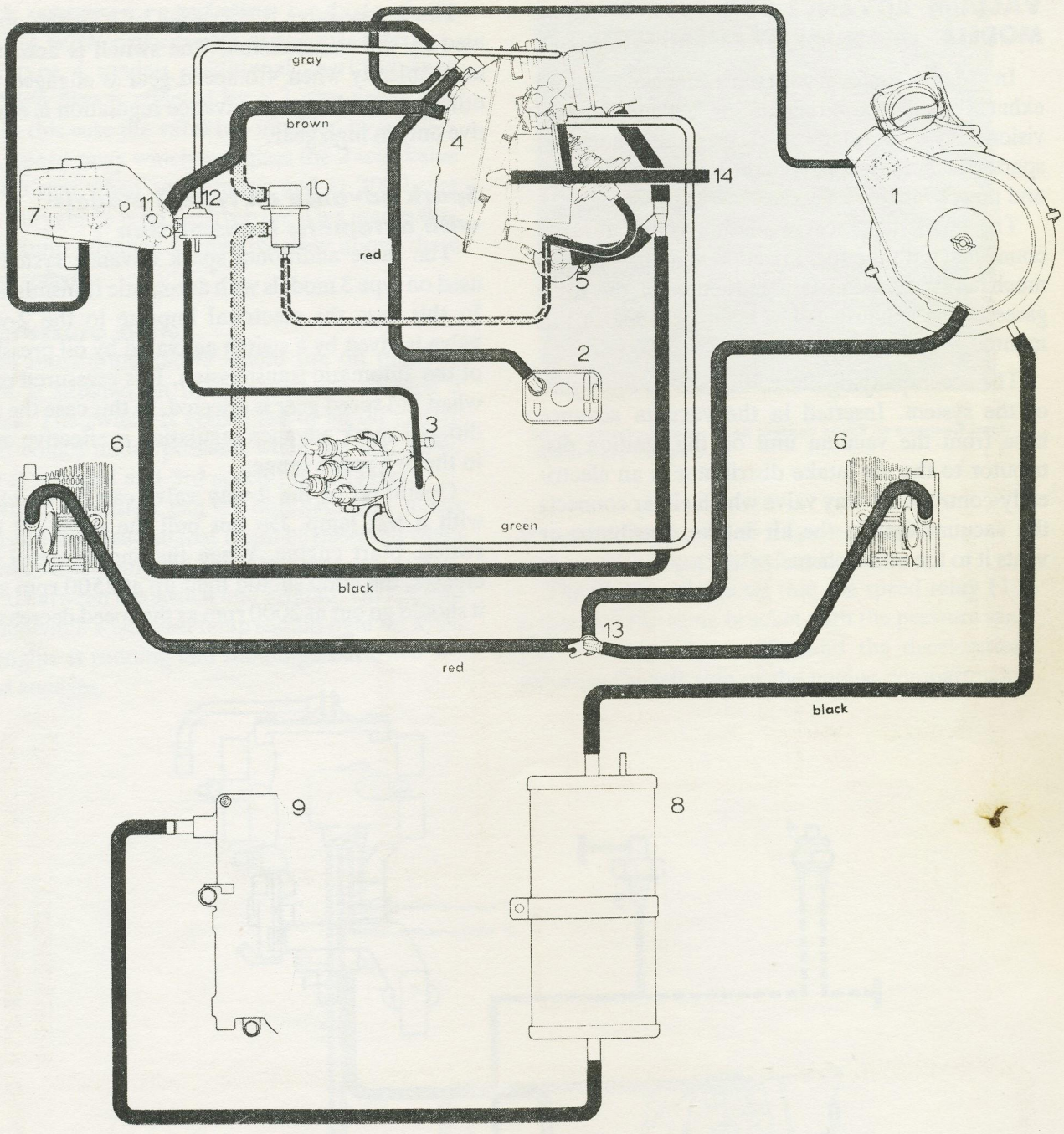
Layout of hoses in engine compartment (late models)

Due to additional equipment used in late type 3 and 4 models, some additional hoses are fitted in the engine compartment. These hoses are of different color in order to avoid incorrect connections. The accompanying illustration shows the layout of the hoses.



Layout of hoses in engine compartment (late type 3 models)

1. oil bath aircleaner
2. oil breather
3. ignition distributor
4. intake air distributor
5. auxiliary air regulator
6. cylinderhead
7. pressure sensor
8. activated charcoal container (some export models only)
9. elbow on fanhousing (left)
10. deceleration valve (pneumatic, manual transmission; some export models only)
11. deceleration valve (electro-magnetic, auto-transmission; some export models only)
12. 2-way valve for ignition vacuum (some export models only)
13. hose to automatic transmission



Layout of hoses in engine compartment (late type 4 models)

1. oil bath aircleaner
2. oil breather
3. ignition distributor
4. intake air distributor
5. auxiliary air regulator
6. cylinderhead
7. pressure sensor
8. activated charcoal container (some export models only)
9. fan housing
10. deceleration valve (pneumatic, manual transm. Some export models only)
11. deceleration valve (electro-magnetic, autom. transm. Some export models only)
12. two way valve for ignition vacuum (some export models only)
13. flame trap
14. to automatic transmission

VACUUM ADVANCE FOR TYPE 3 MODELS (MANUAL TRANSMISSION)

In order to conform with the ever more stringent exhaust gas emission regulations, yet another provision had to be made to restrict the amount of spark advance, especially in the lower engine speed and power ranges.

The spark advance regulation is not directly connected with the fuel injection system, but inasmuch as its function is a reduction of the toxic gases in the exhaust, it has been included in this manual.

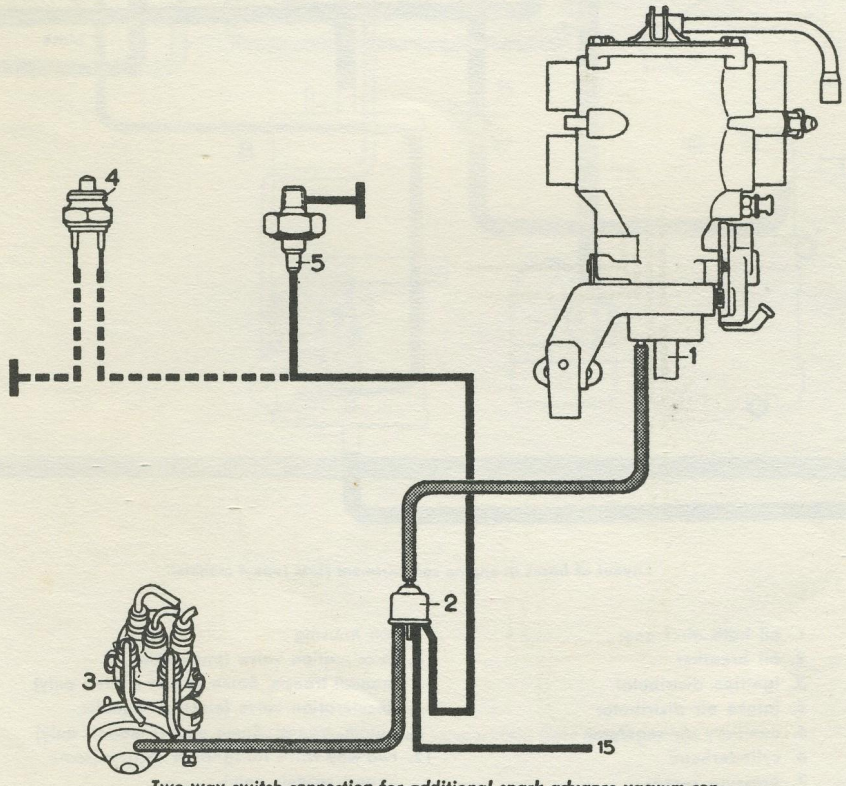
The accompanying illustration shows the layout of the system. Inserted in the vacuum advance hose from the vacuum unit on the ignition distributor to the air intake distributor is an electrically-controlled 2-way valve which either connects the vacuum unit to the air intake distributor or vents it to the atmosphere.

The 2-way valve is energized by a switch operated by the transmission. The switch is actuated mechanically when 4th speed gear is engaged. In other words, the spark advance regulation is effective only in high gear.

Spark advance on type 3 models with automatic transmission

The same additional spark advance system is used on type 3 models with automatic transmission. In this case the electrical impulse to the 2-way valve is given by a switch activated by oil pressure of the automatic transmission. It is pressured only when 3rd speed gear is selected. In this case the additional spark advance regulation is effective only in the 3rd speed range.

Operation of the 2-way valve can be checked with a test lamp. Do not pull the wires off the switch. Start engine. When the engine speed increases, the lamp should light up at 2500 rpm and it should go out at 2000 rpm as the speed decreases.



Two-way switch connection for additional spark advance vacuum control on type 3 vehicles. The switch is activated when 4th speed gear is selected

1. intake air distributor
2. 2-way valve
3. ignition distributor
4. transmission switch (manual trans.)
5. transmission switch (autom. trans.)

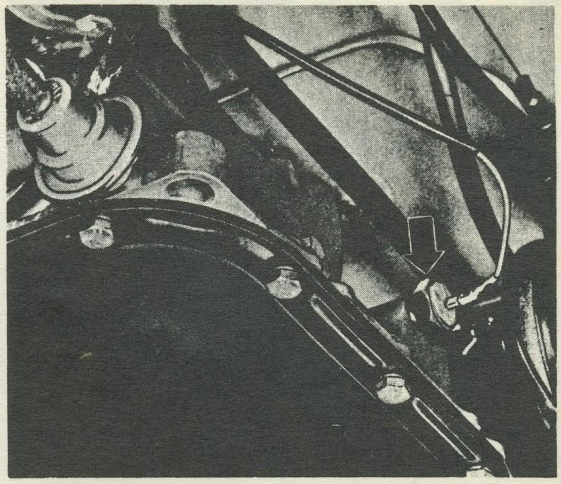
Spark advance regulation on type 4 models with automatic transmission

On type 4 models, additional spark advance regulation also is effected by a 2-way valve (see ill.). In this case the valve is controlled by an electronic speed relay which energizes the 2-way valve at 2500 rpm when accelerating and at 2000 rpm when the vehicle is on the overrun. This means that the vacuum advance is effective only above these engine speeds.

Oil pressure switch

The illustration shows where the oil pressure switch is situated on the transmission of type 3 models. The switch is connected to an oil gallery which comes under pressure when the 2nd speed band is released and 3rd speed gear engages.

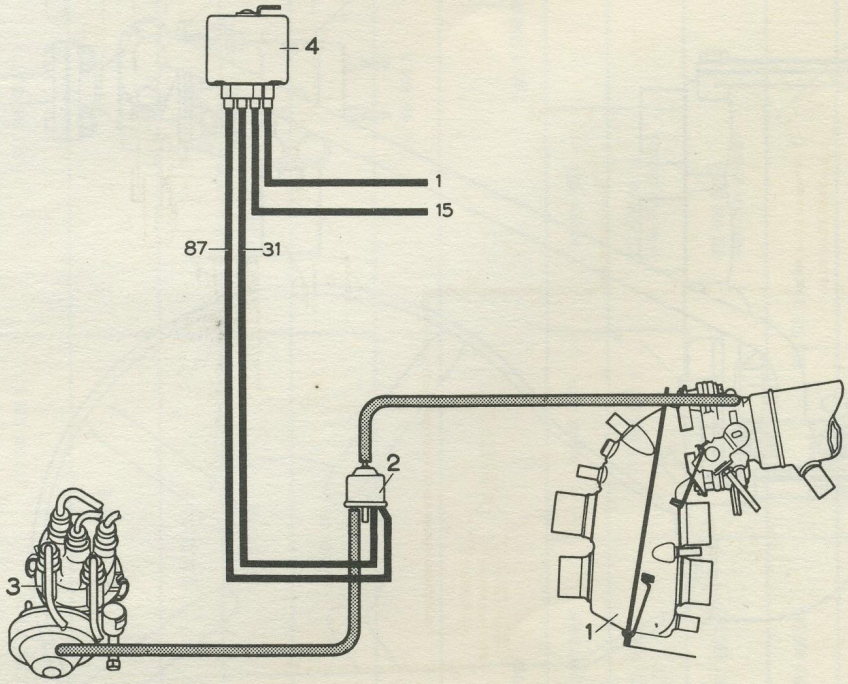
Switch operation can be checked with a test lamp and long lead so that it can be observed when the vehicle is being driven. The test lamp is connected between the switch and ground. Do not pull off the switch wire. Test lamp should light up when the engine is running and should go out when 3rd speed engages.



Arrow indicates location of oil pressure switch on automatic transmission (type 3 models)

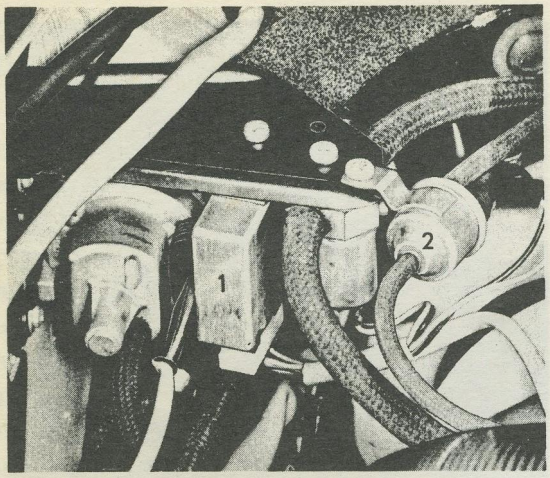
Speed relay switch (type 4 with automatic transmission)

The illustration shows that the speed relay (1) is fitted on the same bracket with the pressure sensor, the 2-way valve (2) and the deceleration valve on the left side of the engine compartment.



On the type 4 models, spark advance in the lower speed ranges is controlled by a 2-way valve and an electronic speed relay. Wires 1 and 15 are ignition coil connections

1. intake air distributor
2. 2-way valve
3. ignition distributor
4. electronic speed relay



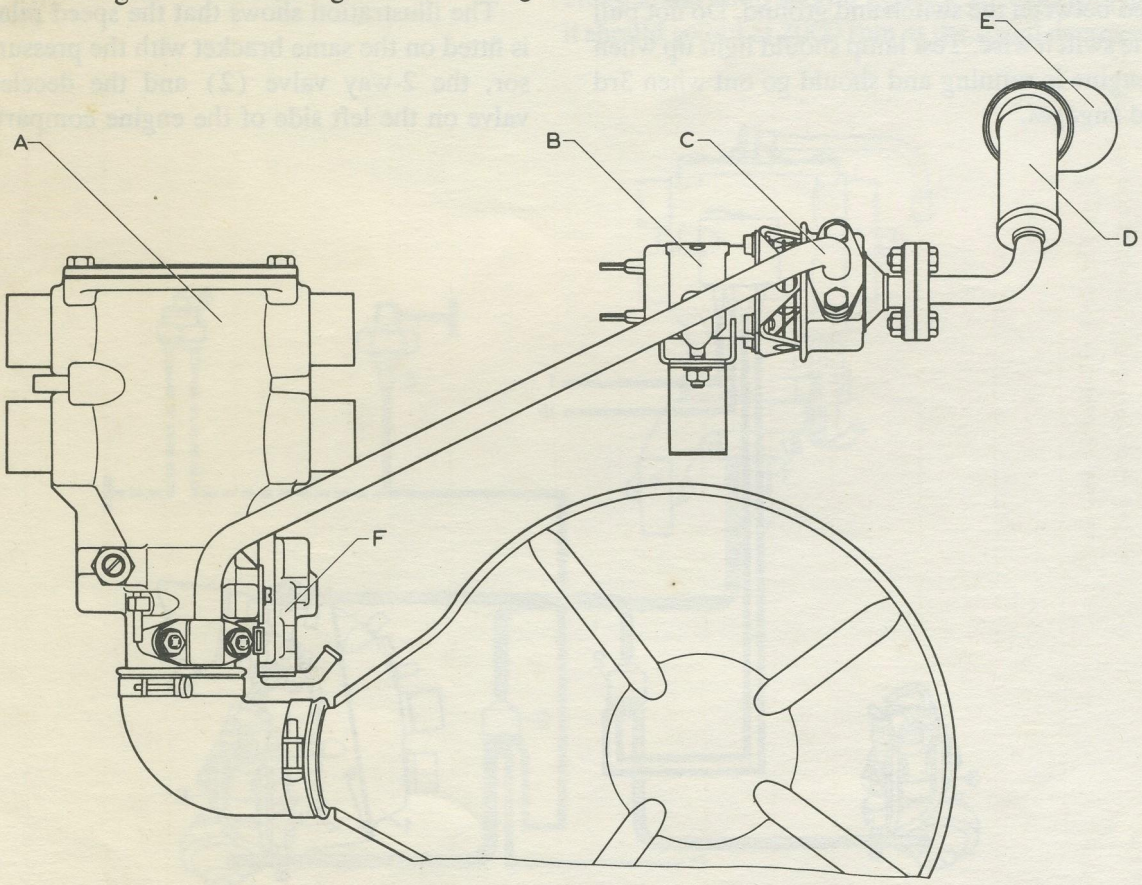
Electronic engine speed relay (1) is fitted on same bracket with two-way valve (2), the pressure sensor and deceleration valve (type 4 models)

EXHAUST GAS RECIRCULATION

In order to reduce the nitrogen oxide content in the exhaust gases an exhaust gas recirculating system is used on type 3 models with automatic transmission. The accompanying illustration shows the principle of this system.

The system is operative only during part-load operation when combustion of the fuel-air mixture is incomplete. Exhaust gas which is cleaned and cooled in the cyclone filter is recirculated into the intake system during part-load operation.

The exhaust gas recirculating valve controls the recirculation. The valve is open when not receiving electrical current. Recirculation takes place under the following conditions: 1. intake air temperature must be above 18°C (65°F). 2. engine in part-load operation (throttle valve in part-load position, i.e. neither the idle or full load contacts are touched). 3. first or second speed must be selected independent of the selector lever.



Components of exhaust gas recirculation system (type 3 models with automatic transmission)

A. intake air distributor
B. exhaust gas recirculating valve
C. pipe line
D. cyclone filter
E. filter container
F. throttle valve switch

TABLE OF VARIOUS UNITS USED IN THE FUEL INJECTION SYSTEM THROUGH THE YEARS

Type 3 1600

Unit	August 1967	April 1968	August 1969	March 1970	April 1970	November 1970	Instructions
Electronic control unit (stock part)	311 906 021 A	311 906 021 B	311 906 021 C		311 906 021 D	311 906 021 D (with black sticker)	Control units with black stickers should not be used together with temp. sensor 1 No. 311 906 081 B
Electronic control unit (replacement part)	311 906 021 B		311 906 021 D 311 906 021 D (with black sticker)				When control unit 311 906 021 D is substituted for 311 906 021 C, be sure to also fit temp. switch 311 906 161 C
Pressure sensor	311 906 051 B		311 906 051 C				
Temp. switch	311 906 161		311 906 161 A	311 906 161 C			In order to alleviate cold start difficulties around 0°C (32°F), a temp. switch No. 311 906 161 B is available
Temp. sensor I (intake air distr.)	311 906 081		311 906 081 A				In case of excessive fuel consumption, temp. sensor 311 906 081 B can be used
Temp. sensor II (cyl. head)	311 906 041 A						

Type 4 1700 **Type 4 1700 (USA version)**

Unit	August 1969	August 1970	January 1971			
Electronic control unit (stock part)	022 906 021	022 906 021 A	022 906 021 A (with blue sticker)		022 906 021 B	Control units with blue stickers should not be used together with temp. sensor II No. 022 906 041 A
Electronic control unit (replacement part)	022 906 021	022 906 021 A	022 906 021 A (with blue sticker)		022 906 021 B	
Pressure sensor	022 906 051	022 906 051 A			022 906 051 B	Pressure sensor 022 906 051 B can be substituted for pressure sensor 022 906 051 A
Temp. switch	311 906 161 A	311 906 161 C				
Temp. sensor I (intake air distr.)	311 906 161 A					
Temp. sensor II (cyl. head)	311 906 081 A					In cases of excessive fuel consumption temp. sensor No. 022 906 041 A can be used
Wiring harness	Wiring harnesses are available with or without connections for a cold starting device. The cold start connections can be cut off and insulated if not needed					

AUTHORITATIVE TECHNICAL MANUALS ON VOLKSWAGEN AND PORSCHE CARS

by HENRY ELFRINK

VOLKSWAGEN TECHNICAL MANUAL
(EARLY TYPE 1 MODELS)
(All About the Volkswagen)

A comprehensive technical manual on the 1950 through 1964 VW beetle models. This book covers the earlier engines and the split-type transmission, the early front suspension and steering boxes. The early tunnel-type transmissions and roller-type steering boxes also are covered. There are sections on speed-tuning, installing a by-pass oil filter, tolerances and wear limits, engine and chassis numbers, electrical system, carburetion, brakes, modifications since 1950, etc., etc.

VOLKSWAGEN 1300/1500 TECHNICAL MANUAL
(LATE TYPE 1 MODELS)

A new book on the latest type 1 (i.e. the beetle) models powered with the 1300 cc and 1500 cc engines. This 368 page book contains hundreds of clear illustrations, including many exploded views (line drawings) showing the exact interrelationship of the various parts. Also very convenient are the color-coded wiring and chassis diagrams. Detailed information on engine overhaul, servicing transmission, carburetion, steering gear, dual-circuit braking system and disc brakes, electrical system, tolerances and wear limits, etc., etc. Invaluable for mechanic, owner or enthusiast.

VOLKSWAGEN 1600 TECHNICAL MANUAL
(TYPE 3 MODELS)

This large technical manual is similar to the one described above but directed toward the VW 1600 type 3 models such as the Variant and the fastback. A very convenient manual for owner and workshop alike. All servicing procedures are given in every day understandable terms. This book also contains many line drawings of exploded assemblies showing just where every part goes. A complete list of tolerances and wear limits is included.

PORSCHE TECHNICAL MANUAL

An outstanding technical manual on Porsche types 356 A, B and C. Detailed repair and maintenance instructions on all pushrod-engined Porsches. 296 pages of solid technical information for owner, mechanic or engineer. There is detailed information on the servicing of engine, transmission (4 types), ZF differential, running gear, electrical system, carburetion, steering gear, suspension, brakes, etc., etc. This manual with 288 pages and many specially-made drawings and cutaways is a must for anyone interested in the Porsche automobile.

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