BOSCH AFC FUEL INJECTION SYSTEM

BMW
528i
633CSi
733i
Datsun
200SX
280ZX
810
Fiat (Calif.)
Brava
Spider (Federal Option)
Strada
X1/9
Jaguar
XJ6
Porsche
928
Toyota
Cressida
Supra
Triumph (Calif.)
TR7
TR8
Volkswagen
Vanagon

NOTE — *The Bosch AFC Fuel Injection system is used on all models and variations between model application occur with auxiliary control systems. This article covers the Bosch AFC system in general, with manufacturer's differences noted.*

DESCRIPTION

The Bosch Air Flow Controlled (AFC) fuel injection system is an electronically controlled system. The Electronic Control Unit (ECU) monitors electrical signals from various sensors, indicating changing operating conditions; such as intake air volume and temperature, coolant temperature, engine load, acceleration/deceleration and exhaust gas oxygen content (some models). The ECU analyzes these signals and determines the fuel injection duration necessary for optimum air/fuel ratio. See *Fig. 1*.

An air flow meter, mounted between the throttle chamber and air cleaner, is the major control unit in addition to the ECU. The air flow to the engine is monitored by the ECU and fuel is adjusted accordingly by timing injector delivery. Injector delivery is based upon amount of intake air required for one engine rotation. The AFC system maintains constant fuel pressure and maintains proper air/fuel mixture by adjusting quantity of fuel to amount of intake air.

A "Closed Loop" feedback system is incorporated into the Bosch AFC fuel injection system by various manufacturers. The system consists of an oxygen sensor (2 on TR8) mounted in the exhaust manifold, special 3-way catalytic converter and special electronic control unit with feedback monitor system. Some systems also employ a modulating valve or frequency valve. Oxygen sensor feedback systems are used on the following models:

- All BMW Models
- Calif. Datsun 280ZX & 810
- Calif. Fiat Brava, Strada & X1/9
- All Fiat Spider 2000

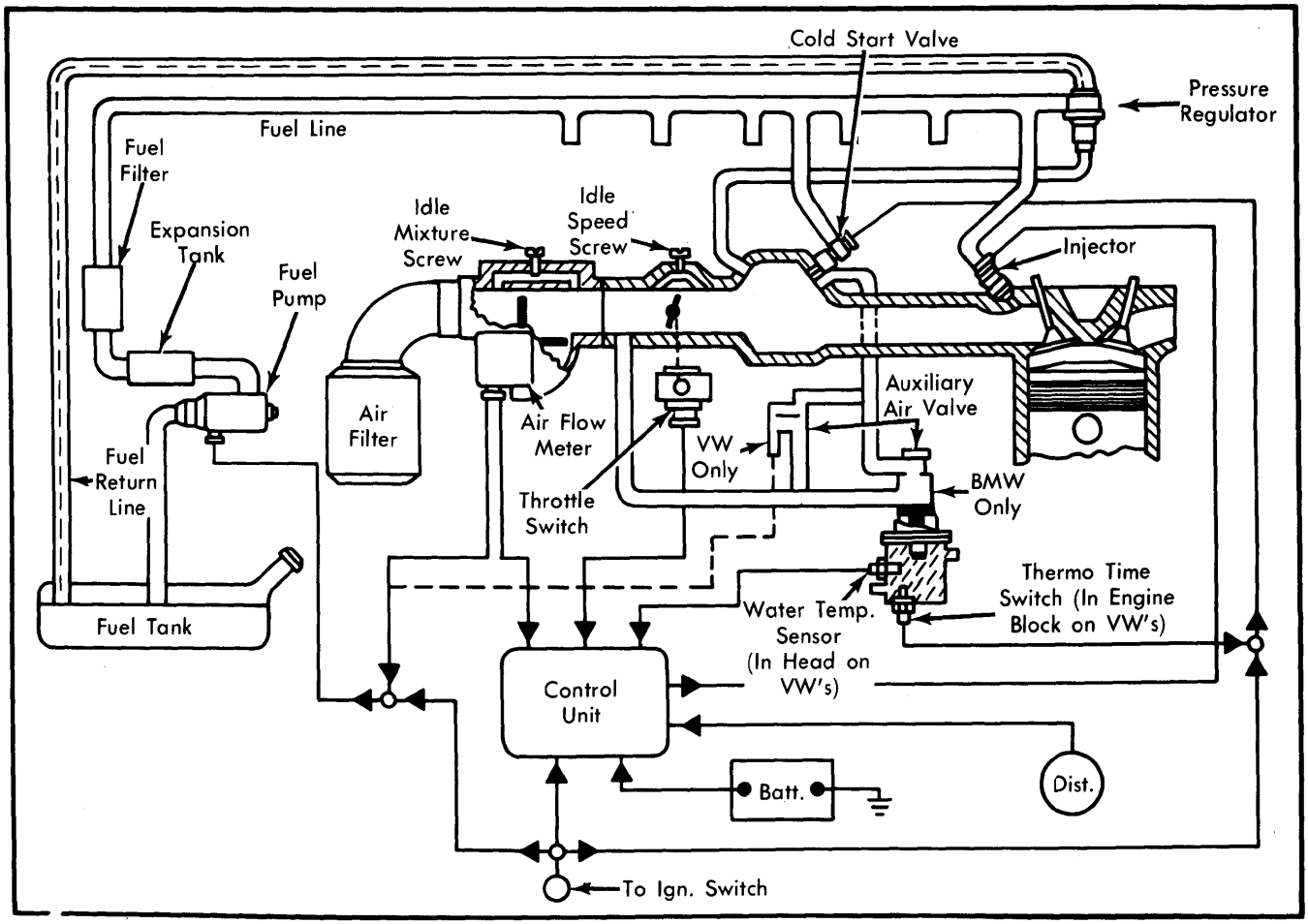

Fig. 1 Diagram of Bosch AFC Fuel Injection System (Exc. Datsun 280ZX & 810)

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

- All Jaguar Models
- All Porsche 928
- Calif. Toyota Cressida & Supra
- All Triumph Models
- Calif. Volkswagen Vanagon

OPERATION

FUEL SYSTEM

Fuel under pressure from electric fuel pump, flows through a pulsation damper (some models) to a pressure regulator. The pressure regulator consists of a sealed, spring loaded diaphragm with a connection for intake manifold vacuum. Fuel pressure differential is maintained at approximately 36 psi (2.5 kg/cm²) between fuel pressure and intake manifold vacuum to ensure amount of fuel injected is solely dependent upon injector "open" time. Fuel in excess of fuel differential is returned to the fuel tank. To aid in cold engine starting, a cold start valve (injector) is activated by a thermo-time switch (except Datsun 200SX) to increase quantity of fuel to combustion chambers.

FUEL INJECTORS

A fuel rail links the fuel pressure regulator with fuel injectors. Each cylinder is provided with a solenoid operated injector, mounted to directly spray fuel towards back of each inlet valve. Each injector is energized through the distributor (coil) and grounded through the ECU to complete the electrical circuit. Each injector is linked in series to a resistor (except TR7 and all Fiat models) which reduces operating voltage of the injector and also protects injector from power surges. The ECU controls the electrical pulsations required to open each injector and the length of time each injector is open. Therefore, no fixed relationship exists between injector timing and ignition timing or valve timing. The time that the injectors are open governs the amount of fuel delivered and the time is controlled by interpretation of sensor impulses received by the ECU. Each injector opens at the same time to deliver ½ the fuel required for ideal combustion with each engine revolution.

AIR FLOW SYSTEM

Air is drawn in through air cleaner and is measured by the air flow meter. Air then travels through throttle chamber and into intake manifold. A throttle valve in the chamber controls air flow while driving. At idle, throttle valve is almost closed and air is drawn through a by-pass port in throttle chamber. Idle speed adjusting screw controls quantity of air intake at idle. During warm-up operation, extra air is by-passed through air regulator to increase engine RPM.

The oxygen sensor detects the amount of oxygen in the exhaust gases. If the sensor senses too much or too little oxygen in the exhaust gases, a change in voltage is produced in the sensor and is transmitted to the ECU. The ECU then changes the amount of fuel injected by using the modulating valve to vary

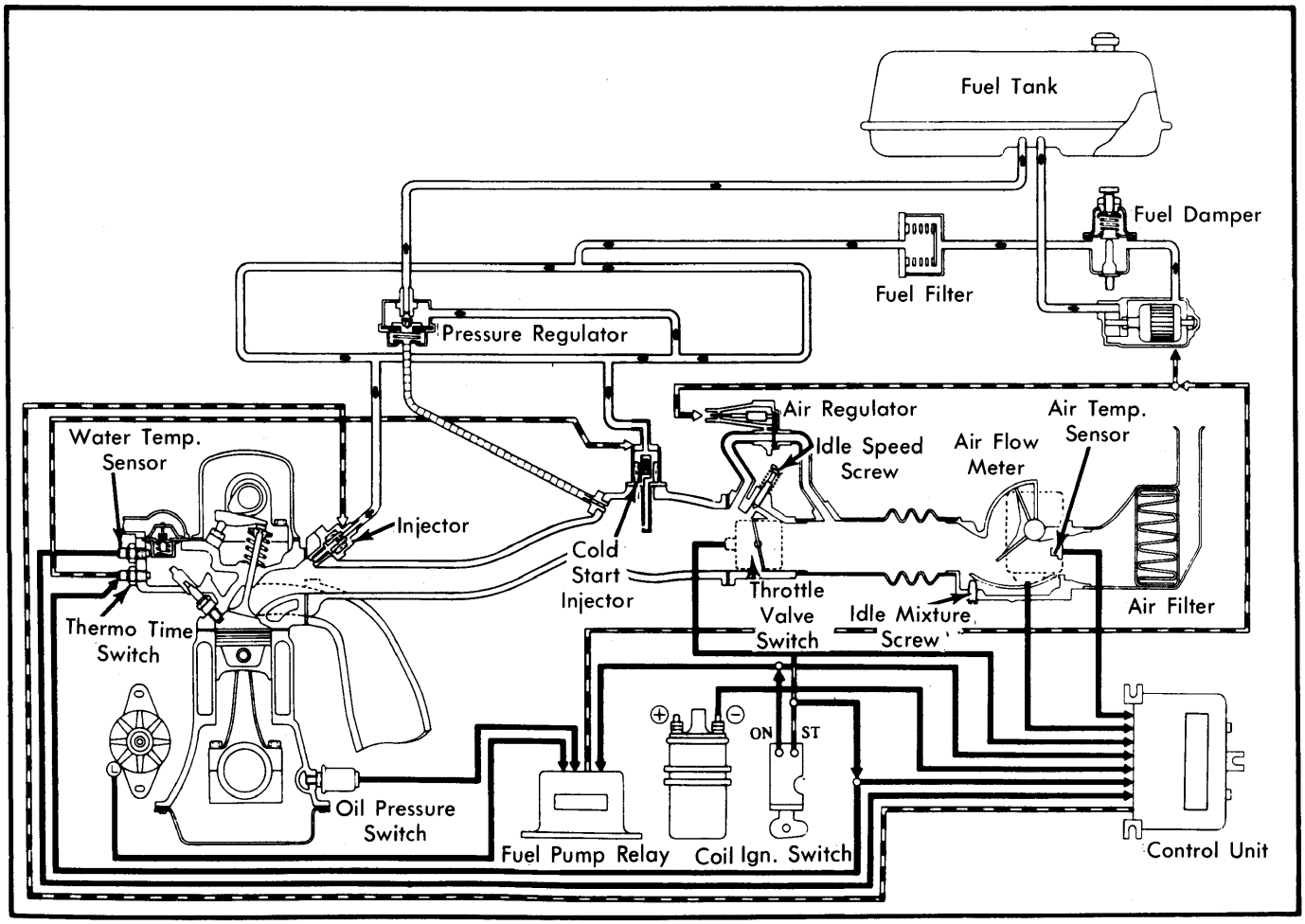

Fig. 2 Diagram of Bosch AFC Fuel Injection System (Datsun 280ZX & 810)

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

the length of time injectors are on. This varying injection time leans or richens the air/fuel ratio, keeping the air/fuel ratio very close to the stoichiometric value of 14.5 to 1.

ELECTRONIC CONTROL UNIT (ECU)

All components of the control system are electrically connected to the electronic control unit. See *Fig. 3*. The ECU is a pre-programmed computer which receives and interprets data from various sensors to calculate the amount of fuel required by the engine to maintain maximum efficiency with minimum exhaust contamination. The ECU controls the injection pulses and injects the correct amount of fuel by controlling length of time injectors are held open. An automatic function of the ECU is to provide fuel enrichment whenever engine is cranked, regardless of engine temperature. This is activated by a direct electrical connection from the starter circuit to the ECU.

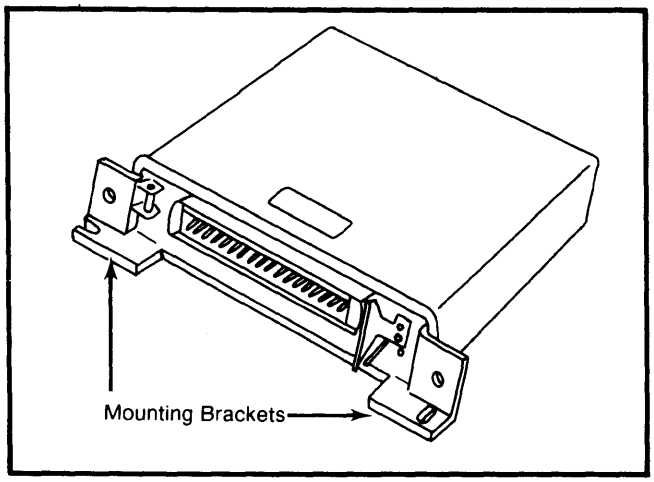

Fig. 3 Electronic Control Unit (ECU)

AIR FLOW METER & POTENTIOMETER

The air flow meter measures the amount of air entering from air cleaner to the throttle housing. The air flow meter is basically a tunnel with a similarly shaped measuring flap and dampening flap (offset 90° on same casting). The measuring flap swings on an axis in air stream against reverse pressure of a spiral spring. The measuring flap is linked to a variable potentiometer which regulates the voltage sent to ECU, depending upon angular displacement of flap as it opens and closes in relation to air flow. See *Fig. 4*.

In addition to monitoring air flow, the air flow meter also controls the fuel pump (except Datsun models) and idling. Within the potentiometer is an electrical contact for fuel pump relay. With engine stopped, no air flow is present, fuel pump contact is open and fuel pump is inoperable. While engine is being started, fuel pump is supplied power from starter relay via the combination relay. Once engine starts, fuel pump contact closes and fuel pump operation is controlled by open position of air flow measuring flap. If flap closes, fuel pump contacts open and power is cut to fuel pump. At idle, the measuring flap is almost closed due to spiral spring pressure. An idle air by-pass channel receives air from main air flow through a small hole, the size of which is controlled by the idle speed adjusting screw. The idle speed adjusting screw also controls quantity of air and exhaust emissions during idle speeds.

NOTE – *Datsun fuel pumps operate on same basic principle, except engine operating mode is sensed by engine oil pressure and alternator output. BOTH oil pressure and alternator output must be lost to break fuel pump relay. Manufacturer recommends thorough test of system to preclude faulty diagnosis of related fuel system components.*

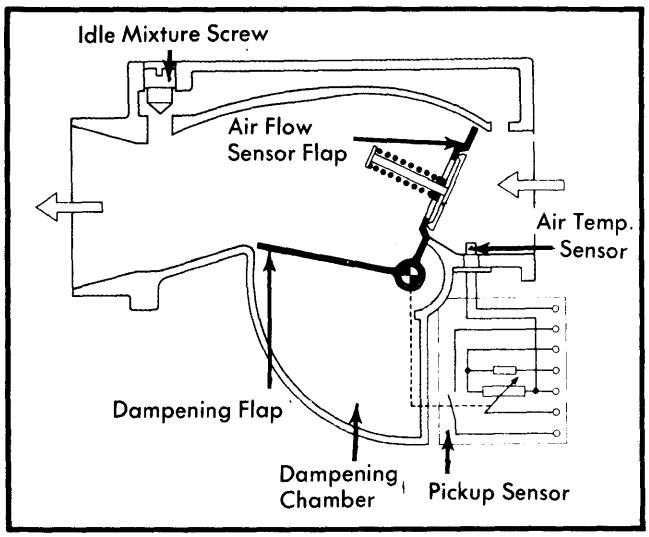

Fig. 4 Air Flow Meter Schematic

AIR TEMPERATURE SENSOR

The air temperature sensor provides the control unit with voltage signals. The temperature of incoming air is converted to electrical impulses which are used by the ECU to adjust engine fuel requirements. The higher the intake air temperature, the lower the electrical impulse; less fuel is required at higher temperatures because of the vaporization ability of warm air. The air temperature sensor is integral with the air flow meter and cannot be serviced or repaired.

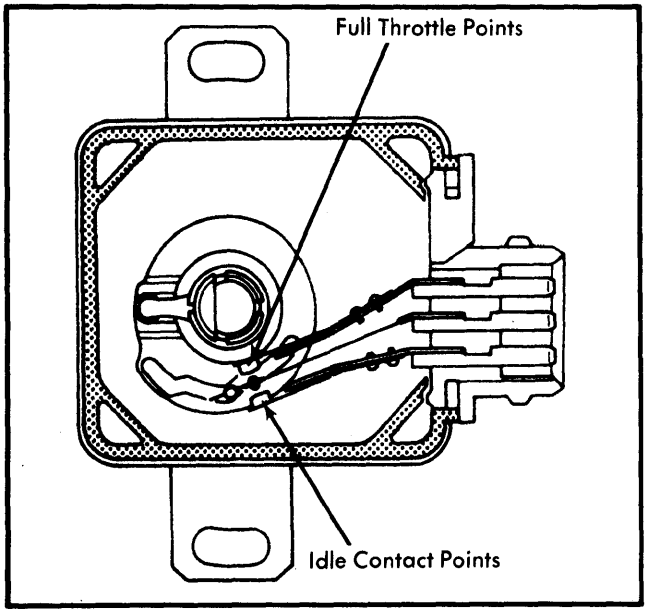

Fig. 5 Typical Contact Type Throttle Switch

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

THROTTLE VALVE SWITCH

A potentiometer type throttle switch is installed on throttle chamber of TR8 models and a contact type is used on all other models. Both throttle switches send electrical impulses to ECU with information on throttle position. On contact type switch, signals are sent to ECU when throttle is fully open or fully closed. See *Fig. 5*. The potentiometer type monitors the throttle plate angle at all times and through variable resistance, electrical impulses are sent to ECU. The throttle switch on Porsche models deactivates the oxygen sensor during vehicle coasting and when throttle valve is opened more than 30°. This lowers exhaust gas temperatures.

ENGINE COOLANT SENSOR

This sensor provides ECU with engine temperature information relating to cold starting and warm-up enrichment operation. The coolant sensor operates in conjunction with cold start system and auxiliary air valve to provide same function as an automatic choke on carbureted engines. As coolant temperature increases, enrichment decreases until engine reaches normal operating temperature.

NOTE – *Any reference made to coolant temperature implies cylinder head temperature for Volkswagen.*

AUXILIARY AIR REGULATOR

The auxiliary air regulator provides additional air required to aid in cold engine starting and initial warm-up. The valve consists of an electrically heated bi-metal strip, movable disc and air by-pass channel. The bi-metal strip is wrapped with a heater coil which is energized by the fuel pump relay. Control of the bi-metal plate is done by engine coolant temperature (except Datsun models). The air by-pass channel is open when engine is cold and closes gradually as temperature rises. At predetermined temperatures, air by-pass channel is blocked and additional air flow stops. See *Fig. 6*.

NOTE – *Control of Datsun auxiliary air regulator is by monitoring engine oil pressure and alternator output. For more information see "Air Flow Meter" in this article.*

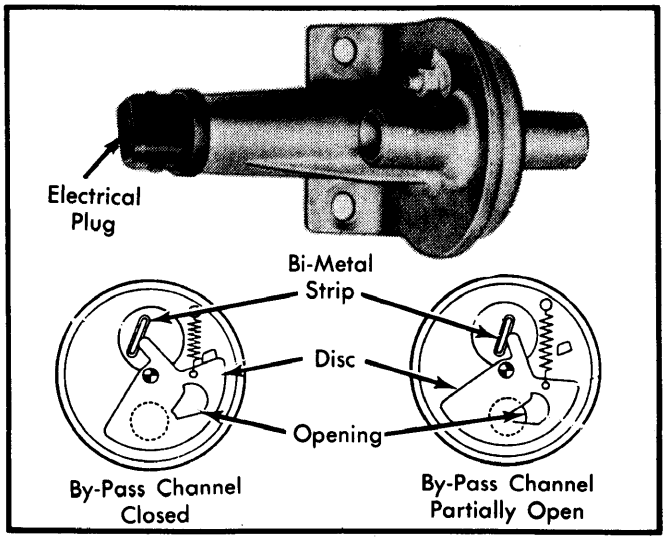

Fig. 6 Typical Auxiliary Air Regulator

THERMO-TIME SWITCH

For cold starting, additional fuel is injected into intake manifold by the cold start injector (valve). This cold start aid is controlled by the thermo-time switch. The switch has a bi-metal contact, surrounded by a heating coil which is energized during cranking. Thermo-time switch limits cold start relay to 5-20 seconds under extreme cold engine starts. When engine coolant temperature is above 95°F (35°C), bi-metal contact breaks ground circuit of cold start injector (valve) and cold start enrichment is by-passed.

NOTE – *Datsun 200SX is not equipped with cold start aid.*

VACUUM SWITCH

All Datsun, Jaguar, Toyota and Triumph models are equipped with a switch to compensate for high load/low manifold vacuum conditions when full throttle contacts have not been activated. Upon acceleration, additional fuel is required and is provided by this switch.

ELECTRICAL RELAYS

Various relay combinations are used by model application. However, most common relays are main relay which activates the ECU, injector circuit and starting circuit when ignition is switched to start mode and fuel pump relay which activates fuel pump during engine start mode and is then controlled by air flow during operating mode (except Datsun models). Datsun models are equipped with a fuel pump control relay which monitors engine oil pressure and alternator output for deactivating fuel pump upon engine failure when ignition switch is left "ON".

TESTING

NOTE – *This fuel injection system maintains constant fuel pressure in fuel lines and component parts at all times. Be sure to relieve pressure before attempting to open system at any point for testing. Do not allow fuel to flow onto engine or electrical parts. Do not allow open flame in area while testing fuel system components.*

ELECTRONIC CONTROL UNIT (ECU)

Do not attempt to test electronic control unit, as permanent damage could result. It is possible to check plug wires for continuity. The electronic control unit should only be judged faulty after compression is checked, the ignition system (particularly breaker points) has been tested and found problem-free, and all other fuel injection components have been thoroughly tested (including wiring).

FUEL PRESSURE

BMW, Fiat, Porsche & VW – 1) Disconnect negative battery cable and release fuel system pressure. Connect fuel pressure gauge between fuel rail and fuel pressure regulator.

2) Disconnect vacuum line at pressure regulator. Reconnect battery and start engine (operate starter on Fiat). Read pressure. On all models except Fiat, reconnect vacuum hose.

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

With vacuum hose connected, pressure should read approximately 28 psi (2.0 kg/cm²). if pressure is not as specified, ensure proper operation of fuel pump and replace pressure regulator and repeat test.

3) On Fiat models, if pressure reading is lower or higher than specified, pinch return fuel line. If pressure increases, replace regulator. If pressure remains constant, check fuel pump operation and fuel line. If no reading is measured, replace fuel pump and repeat test.

NOTE – *On BMW 733i, detach plugs at air sensor. Connect terminals 36 and 39 with jumper wire. Turn ignition ON. A click indicates pump relay is good; a humming sound means fuel pump is running. If no fuel is delivered, the pressure relief valve or check valve in fuel pump is defective. Fuel pump pressure should be 34-38 psi (2.4-2.7 kg/cm²).*

Jaguar & Triumph – 1) Release pressure from main fuel line at cold start injector and connect fuel pressure gauge. Disconnect negative lead from ignition coil and turn ignition switch "ON".

2) Note pressure reading. Slow pressure drop is permissible; sudden pressure drop requires check of entire fuel system.

3) On Jaguar only, operate fuel change-over switch on dash and recheck reading. Reading from both fuel tanks should agree. On all models, if pressure reading is not to specifications, replace fuel pressure regulator.

NOTE – *Datsun recommends using Kent-Moore Electronic Fuel Injection Analyzer (J-25400) to perform tests on any component of fuel injection system. Follow manufacturers' instructions.*

Datsun & Toyota – 1) Disconnect negative battery cable. On Toyota, disconnect electrical connector at cold start injector. On all models, release fuel line pressure. Install fuel pressure gauge to cold start injector (Toyota) and between fuel rail and fuel filter hose (Datsun).

2) Start engine. On Toyota, disconnect and plug vacuum hose at pressure regulator. On all models, note pressure reading. If pressure reading is higher than specified, replace regulator and repeat test. If pressure is lower, check fuel line, fuel filter and fuel pump.

3) On Toyota, reconnect vacuum hose at pressure regulator. Fuel pressure reading should stabilize at 28 psi (2.0 kg/cm²). If above specification, replace pressure regulator. Stop engine. If fuel pressure drops quickly, check fuel pump, pressure regulator and/or injectors.

Fuel Pressure Specifications

Application	Pressure
BMW①	34-38 psi (2.4-2.7 kg/cm²)
Datsun	30 psi (2.1 kg/cm²)
Fiat①	35 psi (2.5 kg/cm²)
Jaguar & Triumph	35.5-37 psi (2.5-2.6 kg/cm²)
Porsche & VW	35 psi (2.5 kg/cm²)
Toyota②	33-38 psi (2.3-2.7 kg/cm²)

① – Vacuum line disconnected at regulator.
② – Regulator vacuum line disconnected and plugged.

4) On Datsun, quickly depress accelerator pedal fully. Fuel pressure reading should immediately read approximately 37 psi (2.6 kg/cm²). If not, replace regulator and repeat test.

NOTE – *Record outside temperature before testing air temperature sensor.*

AIR TEMPERATURE SENSOR

NOTE – *Testing procedures not available for Porsche.*

BMW & Fiat – Turn ignition switch off and disconnect electrical connector at ECU and connect ohmmeter between terminals 6 and 27. Readings should be as follows. If not, replace temperature sensor and air flow meter as an assembly.

Temperature/Resistance Relationship (BMW & Fiat)

Temperature	Resistance (Ohms)
14°F (-10°C)	8,260-10,560
68°F (20°C)	2,280-2,720
122°F (50°C)	760-970

Jaguar & Triumph – Disconnect negative battery cable and air flow meter connector. Connect ohmmeter leads to terminals 6 and 27 on potentiometer connector. Readings should be as follows. If not, replace temperature sensor and air flow meter as an assembly.

Temperature/Resistance Relationship Jaguar & Triumph

Temperature	Resistance (Ohms)
14°F (-10°C)	9,200
32°F (0°C)	5,900
68°F (20°C)	2,500
104°F (40°C)	1,180
140°F (60°C)	600

Datsun (Federal 280ZX & 810, all 200SX) – Turn ignition switch off and disconnect electrical connector at ECU. Connect ohmmeter between terminals 25 and 34. Readings should be as follows. If not, replace temperature sensor and air flow meter as an assembly.

Temperature/Resistance Relationship (Datsun)

Temperature	Resistance (Ohms)
50°F (10°C)	3,250-4,150
68°F (20°C)	2,250-2,750
122°F (50°C)	740-940

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

Toyota – Disconnect air flow meter multi-pin connector and record ambient air temperature. Connect ohmmeter leads to terminals E_2 and THA on potentiometer connector. Ohmmeter readings should be as follows, if not, replace temperature sensor and air flow meter as an assembly.

Temperature/Resistance Relationship

Temperature	Resistance (Ohms)
−4°F (−20°C)	10,000-20,000
32°F (0°C)	4,000-7,000
68°F (20°C)	2,000-3,000
104°F (40°C)	900-1,300

Volkswagen – Turn ignition switch off and disconnect electrical connector at ECU. Connect ohmmeter between terminals 6 and 27. Readings should be 2,500 ohms maximum at 68°F (20°C). If not, replace temperature sensor and air flow meter as an assembly.

AIR FLOW METER & POTENTIOMETER

NOTE – *Testing procedures not available for BMW, Jaguar, Porsche or Triumph models.*

Fiat – Turn ignition switch off and disconnect electrical connector at ECU. Connect ohmmeter between terminals as shown in table and note readings. If readings are not to specifications, replace air flow meter. If readings are correct, check fuel injection system.

Air Flow Meter Resistance (Fiat)

Terminal No.	Resistance (Ohms)
6 & 8	260-520
7 & 8	200-1000
8 & 9	140-280

Datsun (Federal 280ZX & 810; All 200SX) – Turn ignition switch off and disconnect electrical connector at ECU. Connect ohmmeter between terminals shown in table and note readings. If readings are not to specifications, replace air flow meter. If readings are correct, check fuel injection relays.

Air Flow Meter Resistance (Federal 280ZX & 810, All 200SX)

Terminal No.	Resistance (Ohms)
33 & 34	100-400
34 & 35	200-500
32 & 33①	Except 0 & Infinity

① – 200SX terminals 32 & 34 with same results.

Toyota – Turn ignition switch off and disconnect air flow meter connector at ECU. Connect ohmmeter between terminals shown in table and note readings. If readings are not to specifications, replace air flow meter.

Air Flow Meter Resistance (Toyota)

Terminal No.	Resistance (Ohms)
E_2 & Vs	20-100
E_2 & Vc	100-300
E_2 & Vb	200-400
E_1 & Fc	Infinity

Volkswagen – Disconnect electrical connector at air flow meter and connect ohmmeter between terminals shown in table. Note readings. If readings are not to specifications, replace air flow meter.

Air Flow Meter Resistance (Volkswagen)

Terminal No.	Resistance (Ohms)
6 & 9	200-400
6 & 8	130-260
8 & 9	70-140
6 & 7	40-300
7 & 8	100-500

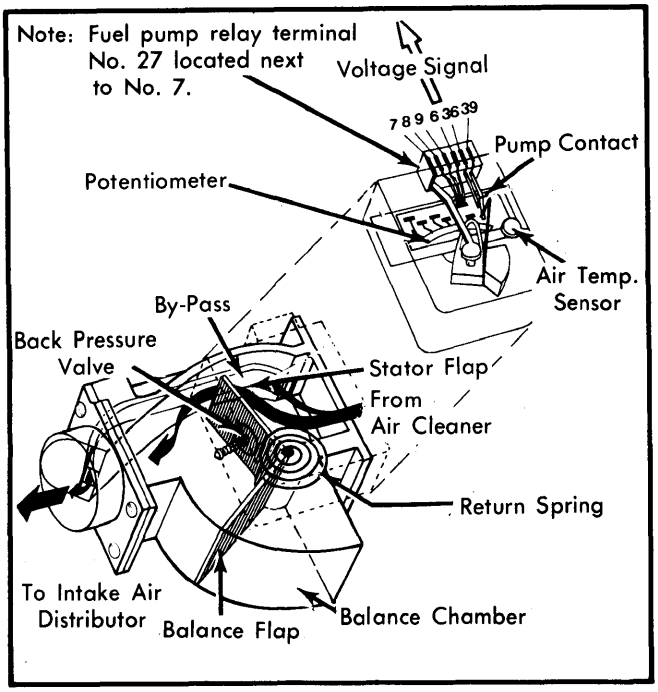

Fig. 7 Air Flow Meter & Potentiometer (Volkswagen Shown – Others Similar)

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

AUXILIARY AIR REGULATOR

NOTE – *Testing procedures not available for Porsche.*

BMW – With engine at normal operating temperature and idle speed set to specifications, turn air conditioner "ON". Connect ohmmeter to black wire of valve connector. Voltage should be registered and air should flow through valve. Turn air conditioner "OFF". No voltage or air should flow through valve. If valve does not function as described, replace air regulator.

Jaguar & Triumph – **1)** Remove auxiliary air regulator connector and connect an ohmmeter to both terminals. Resistance should read approximately 33 ohms. If not, replace auxiliary air regulator.

2) Remove valve from inlet manifold and immerse mounting plate in cold water, avoiding contact of terminals and by-pass channel with water. The movable plate should fully expose air by-pass channel. Gradually heat water and as water temperature increases, channel should be blocked. If not, replace valve.

Datsun, Fiat, Toyota & VW – **1)** With engine warm and at idle speed, pinch-off hose between throttle chamber and air regulator. Engine speed should drop. If not, proceed to next step.

2) Unhook hoses at each end of regulator. Visually check opening in valve. Valve should be open when cold, and close as temperature increases.

3) Check continuity of air regulator at electrical connector. If continuity does not exist, air regulator is defective and should be replaced.

4) Check smoothness of operation by carefully prying air regulator valve open with a flat bladed screwdriver and then close valve again. Replace valve if operation is not smooth.

THERMO-TIME SWITCH

BMW – **1)** Disconnect connector at thermo-time switch. Connect ohmmeter to terminal "G" and ground. Check for 40-70 ohms.

NOTE – *Terminal "W" on 528i thermo-time switch is connector terminal number 86c.*

2) Connect ohmmeter between terminal 85 ("W" on thermo-time switch) and ground. Connect terminal 86 with 30 ("G" on thermo-time switch). For temperatures above 59°F (15°C), you should have an infinity reading. Below 59°F (15°C), you should have a zero reading for 0 to 8 seconds.

Jaguar & Triumph – **1)** Check engine coolant temperature with a thermometer. Compare coolant temperature with value stamped on thermotime switch body. If coolant temperature is higher than switch value go on to step **2)**. If temperature is lower than switch value, go on to step **3)**.

2) If coolant temperature is higher than switch value, connect an ohmmeter between terminal "W" and ground. A very high resistance (open circuit) should be obtained. If not, replace switch.

3) If coolant temperature is lower than switch value, connect an ohmmeter between terminal "W" and ground. A very low resistance (closed circuit) should be obtained. Connect battery voltage via an isolating switch to terminal "G" of thermo-time switch. Using a stop watch, check delay time as ohmmeter changes between high and low resistance. Delay period should be as specified in table. If not, replace switch.

Coolant/Delay Time Relationship (Jaguar & Triumph)

Temperature (Coolant)	Delay (Seconds)
-4°F (-20°C)	8
32°F (0°C)	4.5
50°F (10°C)	3.5
95°F (35°C)	0

Datsun (Except 200SX) – **1)** Disconnect negative battery cable and switch connector. Connect ohmmeter between terminal 45 and ground. Check for 40-70 ohms. Connect ohmmeter between terminal 46 and switch body.

2) Ohmmeter reading should show full continuity (0 ohms) at 57°F (14°C) and infinity reading at 77°F (25°C). If readings are not as specified, replace thermo-time switch.

Fiat – **1)** Disconnect connector from cold start injector. Connect test light between terminals, operate starter and note time test light stays lit. No light should be present if coolant temperature is above 95°F (35°C) and should glow for 1-8 seconds at temperatures below 95°F (35°C).

2) If light does not perform as described, check relay and wiring. If good, replace thermo-time switch.

Toyota – **1)** Disconnect thermo-time switch connector. Connect ohmmeter between terminal STA and STJ on thermo-time switch and measure resistance. Then, measure resistance between terminal STA and ground.

2) Resistance between terminal STA and ground should be 20-80 ohms. Resistance between terminal STA and STJ should be 20-40 ohms with coolant temperature below 95°F (35°C) and 40-60 ohms with coolant temperature above 95°F (35°C).

Volkswagen – **1)** Ensure engine temperature is below 95°F (35°C). Disconnect electrical connector at cold start valve. Disconnect and tape ignition primary connector wire from terminal 1 of ignition coil to prevent engine starting.

2) Attach test light to switch terminals and operate starter. Light should glow from 2-11 seconds at temperatures ranging from −4°-104°F (−20°C-40°C). If light does not glow or perform as described, check wiring harness and replace switch. Test lamp should not glow at temperatures above 104°F (40°C).

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

COLD START VALVE

NOTE – *Testing procedures not available for Porsche or VW.*

BMW – 1) With ignition switch "OFF", disconnect electrical connector from cold start valve. Release pressure from fuel system and remove cold start valve with fuel lines connected.

2) Place container under cold start valve. Disconnect air flow meter connector and connect jumper wire between terminals 36 and 39. Connect another jumper wire between cold start relay terminals 87 and 30. Turn ignition switch "ON". Cold start valve should spray fuel. If not, replace cold start valve.

NOTE – *On 528i, connect lead 61 1 440 to cold start valve, then connect terminal "B+" to ground after jumping air flow connector.*

Jaguar & Triumph – 1) Remove electrical connector from cold start valve and connect voltmeter across connector terminals. Crank engine with ignition switch. Battery voltage should be read.

2) Release fuel system pressure and remove cold start valve with fuel lines connected. Reconnect coupler and place cold start valve in container. As cold engine is cranked with ignition switch, fuel spray should be observed until thermo-time switch cuts off relay. When the engine is warm, no fuel spray should occur during cranking. If valve does not perform as described, replace cold start valve.

Datsun (Except 200SX) – 1) Disconnect battery ground cable. Remove cold start valve with fuel lines connected and place tip in glass container.

2) Disconnect oil pressure switch connector or alternator "L" terminal. Connect battery ground cable. Turn ignition switch "ON". Cold start valve should NOT inject fuel.

3) Turn ignition switch off. Using 2 jumper wires, connect cold start valve to battery. Fuel should be injected. If not, replace cold start valve.

Fiat – 1) Release fuel system pressure and remove cold start valve from intake manifold without removing fuel lines or connector. Place cold start valve in glass container.

2) Turn ignition switch to "START" and crank engine. With engine coolant temperature below 95°F (35°C), fuel should be sprayed for 1-8 seconds; above 95°F (35°C), no fuel should be sprayed.

3) If valve sprays continuously, drips or does not spray fuel at temperature below 95°F (35°C), replace cold start valve.

Toyota – 1) Remove cold start injector from inlet chamber with fuel lines and coupler connected. Remove coupler and install test coupler to valve. Position cold start valve in glass container and keep valve away from electrical connectors.

2) Turn ignition switch "ON" but do NOT start engine. Connect jumper wire to fuel pump check connector terminals (located in wiring harness near air flow meter). Connect test coupler to battery voltage. Fuel should be injected.

3) Disconnect test coupler from battery and check that valve does not leak fuel. Remove jumper wire at fuel pump check connector and test coupler from valve. Connect ohmmeter to cold start valve terminals and check for 3-5 ohms. If cold start valve does not perform as described, replace cold start valve.

WATER TEMPERATURE SENSOR

All Models – Disconnect plug and connect ohmmeter between terminals (Volkswagen) or between terminals and ground (all others). Measure resistance at various temperatures and compare readings to tables.

Temperature/Resistance Relationship (Jaguar, Toyota, Triumph & VW)

Temperature (Coolant)	Resistance (Ohms)
-22° F (-30° C)	20,300-33,000
14° F (-10° C)	7,600-10,800
50° F (10° C)	3,250-4,150
68° F (20° C)	2,250-2,750
122° F (50° C)	740-940
176° F (80° C)	290-360

Temperature/Resistance Relationship (BMW, Fiat & Datsun)

Temperature (Coolant)	Resistance (Ohms)
14°F (-10°C)	7,000-11,600
68°F (20°C)	2,100-2,900
176°F (80°C)	270-390

MIXTURE CONTROL COMPONENTS

Datsun 280ZX & 810 Models (Calif. Only) – 1) Start engine and warm to normal operating temperature. Accelerate and run engine at 2000 RPM for 5 minutes to stabilize operating condition.

2) Accelerate engine 2-3 times and allow to idle. Turn idle speed adjusting screw to obtain 700 RPM. Check ignition timing and adjust if necessary. Raise engine speed to 2000 RPM and observe inspection light on bottom of EFI control unit.

3) Light should blink more than 5 times in 10 seconds, indicating mixture is correct and is being controlled by the computer. If light is blinking properly, system is functioning and no adjustment is required.

4) If not, turn ignition switch off, disconnect negative battery cable and 35 pin connector from control unit. Disconnect exhaust gas sensor harness connector. Ground sensor terminal of connector.

5) Check for continuity between terminal No. 31 of control unit connector and chassis ground. If circuit is open, repair or

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

replace EFI harness and repeat test procedure. If continuity exists, reconnect control unit harness and battery negative cable.

6) Start engine, run at 2000 RPM and observe inspection light on control unit. With exhaust sensor terminal grounded, light should glow. Remove ground wire from sensor terminal and light should go out. If not okay, replace control unit and repeat all test procedures. If okay, proceed to next step.

7) Turn ignition switch off, disconnect throttle valve switch harness connector and connect a jumper wire between harness connector terminals No. 24 and No. 30. Position harness connector at least 4" away from any secondary ignition wires.

8) Disconnect and plug distributor vacuum hose. Disconnect air induction hose and canister purge hose at intake manifold. Plug air induction pipe and purge hose fitting on intake manifold. Start engine, accelerate 2-3 times and allow to idle.

9) Insert CO meter probe into tail pipe (a minimum of 16") and measure CO level. Idle CO level should be less than 5%. If CO level is okay and engine runs smoothly, replace exhaust gas sensor and repeat all test procedures. If CO level is incorrect or if CO level is correct, but engine does not run smoothly, proceed to next step.

10) Turn ignition switch off and remove air flow meter. Drill a small hole in steel plug covering air by-pass screw. Install a self-tapping screw into hole and remove plug. Reinstall air flow meter, start engine and run to normal operating temperature.

11) With engine idling, adjust air by-pass screw to obtain a 0.2-1.8% reading on CO meter. If mixture will not adjust, repair or replace air flow meter or other defective EFI components and repeat all test procedures.

12) If mixture adjusts correctly, replace steel plug in air flow meter and reconnect all hoses and harness connectors. Repeat all test procedures.

REMOVAL & INSTALLATION

NOTE – *This fuel injection system maintains constant fuel pressure in fuel lines and component parts at all times. Be sure to relieve pressure before attempting to open system at any point for testing. Do not allow fuel to flow onto engine or electrical parts. Do not allow open flame or sparks in area while servicing or testing fuel system components.*

AIR FLOW METER & AIR CLEANER

Removal (BMW & Fiat) – Disconnect electrical plug and loosen clamps on both sides of air flow meter. Remove air cleaner and lift air flow meter out of its holder.

Installation (BMW & Fiat) – To install, reverse removal procedure.

Removal (Datsun, Jaguar & Triumph) – Disconnect battery ground cable. Disconnect rubber hose from both sides of air flow meter. Disconnect air flow meter ground cable and remove bolts securing air flow meter to bracket. Move air flow meter upward, disconnect electrical connector and remove air flow meter.

Installation (Datsun, Jaguar & Triumph) – To install, reverse removal procedure.

NOTE – *Removal procedures not available for Porsche.*

Removal (Toyota) – Remove air cleaner inlet pipe, cover and filter element. Remove 4 nuts attaching air cleaner to air flow meter. Remove bracket bolt, hose clamp and hose from end of meter. Disconnect electrical connector and remove air flow meter.

Installation (Toyota) – To install, reverse removal procedures, making sure gasket between air flow meter and air cleaner assembly is properly positioned.

Removal (Volkswagen) – 1) Remove air cleaner top and filter, then carefully remove electrical connector from sensor. Loosen hose clamp then disconnect elbow duct from sensor.

2) Remove nuts securing air cleaner body to vehicle chassis. Remove sensor and air cleaner body as a unit. Now remove sensor from air cleaner body.

Installation (Volkswagen) – To install sensor, reverse removal procedure. Make sure sensor is properly adjusted after installation.

THROTTLE VALVE HOUSING

Removal (BMW & Fiat) – 1) Disconnect and remove air cleaner assembly. Remove engine valve cover. Remove throttle linkage and throttle cable (automatic transmission).

2) Disconnect all vacuum hoses. Always mark or note where vacuum hose was removed from for correct replacement. Disconnect throttle valve switch connector.

3) Drain vehicle coolant below auxiliary air valve or pinch water hoses going to air valve with clamps. Remove hoses from auxiliary air valve. Remove throttle valve mounting bolts and throttle valve.

Installation (BMW & Fiat) – Use new gasket for throttle body, then reverse removal procedure for installation.

Removal (Datsun) – Disconnect battery ground cable. Remove rubber hoses from throttle chamber. Remove throttle valve switch and disconnect BCDD device (if equipped). Disconnect rod from auxiliary throttle shaft. Remove four screws securing throttle chamber to intake manifold. Throttle chamber can now be removed together with dashpot and BCDD device (if equipped).

Installation (Datsun) – To install, reverse removal procedure.

Removal (Toyota) – Drain coolant from radiator. Remove air intake connector, throttle link, water and vacuum hoses. Remove electrical connectors from throttle body. Remove 4 throttle body attaching bolts and throttle body from air intake chamber.

Installation (Toyota) – Reverse removal procedure, using a new throttle body gasket.

Removal (Volkswagen) – 1) Remove intake air sensor and air cleaner as a unit. Loosen clamp and remove elbow ducting from top of throttle valve housing.

2) Disconnect throttle return spring from bracket on EGR valve body. Detach operating rod from EGR valve. Disconnect throttle linkage from arm on throttle valve shaft. Detach upper end of ball link from arm.

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

3) Disconnect vacuum hoses from throttle valve housing, mark hoses for correct position when installing. Remove screws securing throttle valve housing to manifold and remove throttle valve housing.

Installation (Volkswagen) – To install throttle valve housing, reverse removal procedure. Always use a new gasket when installing housing.

CONTROL UNIT (ECU)

Removal (BMW) – Disconnect negative battery cable. ECU is located behind cover at right kick panel on 733i and in glove compartment on all other models. Press back on clip located on wire end of electrical connector and swing cable assembly to right while removing. Remove ECU retaining screws and remove control unit.

Installation (BMW) – To install, reverse removal procedure.

NOTE – *Plug connector on left rear side of harness MUST be connected for BMW vehicles registered in Colorado.*

Removal (Jaguar & Triumph) – Disconnect negative battery cable. ECU is located in glove compartment on TR7; below glove compartment on TR8; and at forward end of luggage compartment on Jaguar. Remove ECU cover, retainer band and cable clamp clip. Unclip end cover and lift out ECU. Disconnect pin connector and remove ECU.

Installation (Jaguar & Triumph) – To install, reverse removal procedure, making sure pin connector is installed squarely and securely.

Removal (Datsun & Toyota) – Turn ignition switch "OFF", then disconnect battery negative cable. Remove left kick panel. Remove cover and 3 bolts securing control unit to side panel bracket. Carefully disconnect pin connector(s) and remove control unit.

Installation (Datsun & Toyota) – To install, reverse removal procedure.

Removal (Fiat) – Disconnect negative battery cable. Under dash panel, press back on clip located on wire end of electrical connector and swing cable to right while removing. Remove ECU retaining screws and remove control unit.

Installation (Fiat) – To install, reverse removal procedure.

Removal (Porsche) – Disconnect negative battery cable. At right kick panel, disconnect connector retainer clamps and remove connector. Remove ECU retaining bolts and remove contol unit.

Installation (Porsche) – To install, reverse removal procedure.

Removal (Volkswagen) – Disconnect negative battery cable. In luggage compartment, near distributor, remove ECU connector by carefully using screwdriver. Position connector where it cannot be damaged physically or electrically. Remove control unit.

Installation (Volkswagen) – To install ECU, reverse removal procedure. Make sure cable plug is carefully and completely engaged in ECU. Be sure new ECU has same part number as one removed. Reattach battery ground cable.

COLD START VALVE

Removal (All Models, Except 200SX) – Disconnect battery ground cable and remove connector at cold start valve. Release fuel line pressure and remove cold start valve retaining screws. Remove cold start valve.

Installation – To install, reverse removal procedure.

AUXILIARY AIR REGULATOR

Removal (Jaguar, Toyota & Triumph) – 1) Disconnect negative battery cable. Disconnect air hoses from auxiliary air valve.

NOTE – *Auxiliary air valve is installed in engine cooling system.*

2) When removing auxiliary air valve from cooling system, either have another valve ready for immediate installation or drain cooling system below level of valve. Remove valve retaining screws and remove auxiliary air valve.

Installation (Jaguar, Toyota & Triumph) – To install, reverse removal procedure.

Removal (All Others) – Disconnect battery ground cable. Remove electrical connector and air hoses at air regulator. Remove retaining screws and remove auxiliary air regulator.

Installation (All Others) – To install, reverse removal procedure.

WATER TEMPERATURE SENSOR

NOTE – *Removal of water temperature sensor should be done only when engine is cold. Removal of sensor requires having replacement sensor ready for immediate installation or draining cooling system below level of sensor.*

Removal (All Models) – Disconnect negative battery cable. Drain coolant and disconnect sensor electrical connector. Loosen and remove engine coolant temperature sensor.

Installation – To install, reverse removal procedure using suitable liquid sealer on sensor threads. Replace sealing washers, if equipped.

THERMO-TIME SWITCH

NOTE – *Thermo-time switch removal should be done only when engine is cold. Removal of switch requires having replacement switch ready for immediate installation or draining cooling system below level of switch.*

Removal (All Models, Except 200SX) – Disconnect negative battery cable and drain radiator coolant (except VW). Disconnect electrical connector from switch and remove switch.

Installation (All Models, Except 200SX) – To install, reverse removal procedure, using suitable liquid sealer on switch threads.

PRESSURE REGULATOR

NOTE – *Throttle body must be removed on Toyota models before removing pressure regulator.*

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

Removal (All Models) – Disconnect negative battery cable and relieve fuel system pressure. Disconnect fuel lines and vacuum line at regulator. Remove pressure regulator (separating from bracket, if installed).

Installation – To install, reverse removal procedure.

INJECTORS

NOTE – *Removal procedures not available for Porsche models.*

Removal (BMW) – **1)** Disconnect negative battery cable and relieve pressure in fuel system. Remove electrical connectors from injectors, fuel line at pressure regulator and fuel return line. Remove injector mounting bolts. Remove fuel rail and injectors as an assembly.

2) Remove injector-to-fuel rail sleeve by cutting sleeve. Remove injector from fuel rail by burning hose with a soldering gun, until assembly can be removed from fuel rail.

Installation (BMW) – To install, reverse removal procedure and ensure new hose is sealed at fuel rail with new sleeve.

Removal (Jaguar & Triumph) – **1)** Disconnect negative battery cable and depressurize fuel system. Disconnect electrical connectors at injectors. Remove 2 screws attaching fuel rail to intake manifold.

2) Release clips holding fuel supply and return rails. Remove manifold pressure pipe. Remove 6 nuts and washers from injector clamps and lift off fuel rail with injectors. Loosen injector clamps and remove injectors from fuel rail.

Installation (Jaguar & Triumph) – To install, reverse removal procedure, making sure electrical connectors are properly installed on injectors before installing fuel rail assembly to manifold.

Removal (Datsun) – **1)** Disconnect negative battery cable and depressurize fuel system. On 200SX, remove accelerator cable and vacuum control valve hose. On all models, disconnect electrical connectors from injectors and cold start valve (except 200SX). Disconnect harness from fuel rail wire clamp. Remove blow-by hose at rocker cover side (except 200SX). Remove air regulator pipe. Disconnect pressure regulator vacuum hose.

2) Disconnect fuel feed and return lines from fuel rail. Remove fuel rail and pressure regulator mounting bolts and all injector retaining screws. Remove fuel rail, pressure regulator and injectors as an assembly. Remove fuel injectors by removing hose clamp on injector and pulling injector from hose.

Installation (Datsun) – To install, reverse removal procedure.

Removal (Fiat) – Disconnect negative battery cable and depressurize fuel system. Disconnect electrical connectors at all injectors. Remove fuel supply hose from fuel rail, fuel return line from pressure regulator, fuel line from cold start valve and vacuum line from pressure regulator. Remove fuel rail mounting bolt and 4 injector retaining nuts. Remove fuel rail, injectors and pressure regulator as an assembly. Remove injectors from fuel rail by pulling off fuel hoses.

Installation (Fiat) – To install, reverse removal procedure.

Removal (Toyota) – **1)** Disconnect battery ground cable and drain coolant. Disconnect (after marking for installation) all vacuum, fuel and water hoses connected to intake air chamber. Remove cold start injector, EGR pipe and throttle link from air chamber. Remove air intake chamber.

2) Unplug electrical connectors from injectors and remove 2 injector harness clamps from fuel delivery pipe. Remove 4 fuel delivery pipe bolts and remove fuel delivery pipe with injectors attached.

Installation (Toyota) – To install, reverse removal procedure, using new "O" rings and seals.

Removal (Volkswagen) – **1)** Remove the large air duct between fan housing and heat exchangers on exhaust system. Disconnect battery and relieve pressure in fuel system.

2) Disconnect electrical connector and fuel lines from injectors to be removed. Remove screw securing injector to intake manifold. Remove injector with seals and retainer plate.

Installation (Volkswagen) – To install injectors, reverse removal procedure.

ADJUSTMENTS

HOT (SLOW) IDLE RPM

See appropriate Tune-Up article in TUNE-UP section.

IDLE MIXTURE

See appropriate Tune-Up article in TUNE-UP section.

OXYGEN SENSOR WARNING LIGHT

1) All vehicles equipped with oxygen sensors are also equipped with an oxygen sensor maintenance interval light. This light is located on the dash panel of all models. Light will come on after a predetermined number of miles, indicating need for oxygen sensor replacement.

2) Service interval is 12,500 for Jaguar and 30,000 miles for all other models. After oxygen sensor replacement, reset the oxygen sensor warning light switch, except Datsun models. On BMW, switch is located on left side of engine near transmission (in line with speedometer cable). On British Leyland, Fiat and VW, switch is on control box located on speedometer cable. On Porsche, switch is located to right of passenger seat. On Toyota, switch is located beneath switch cover on pedal assembly, below instrument panel.

THROTTLE VALVE SWITCH

BMW – **1)** Connect Bosch tester (0684 100 202) to ECU. Set cylinder selector switch to "6" and program selector switch to "5". Turn ignition on. Tester gauge should read 0 ohms with throttle valve at idle position; infinite for partial throttle valve position and 0 ohms for full throttle valve position.

2) If throttle valve switch does not perform as described, loosen throttle switch screws and place throttle valve in idle position. At idle, tester reading should be 0 ohms. When throttle valve is moved .118-.157" (3-4 mm), tester reading should read infinity. If relocating throttle switch does not produce above results, replace throttle switch.

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

NOTE – *Throttle switch contacts can be tested for continuity on 633CSi and 733i models with an ohmmeter. With ohmmeter connected between terminal 18 (center) and 2 (top), 0 ohms should be measured with throttle at idle. With ohmmeter connected between terminal 18 and 3 (bottom), 0 ohms should be measured with throttle at full throttle position.*

Triumph (TR8) – Disconnect electrical connector at throttle switch and connect throttle gauge connector (60973067). With engine at normal operating temperature and idle speed set, adjust until green light glows on throttle gauge. Remove gauge and reconnect harness.

Datsun – 1) With engine running at idle, disconnect throttle valve switch connector. Connect ohmmeter leads to terminals 29 and 30 of throttle valve switch.

NOTE – *Do not connect ohmmeter to throttle valve switch wire connector or damage to ohmmeter may result.*

2) With engine operating at idle, 0 ohms should register on ohmmeter. Loosen throttle switch retaining screw and increase engine idle speed to 900 RPM (770 RPM on 200SX). Adjust location of switch so that ohmmeter reading goes from 0 ohms to infinity. If ohmmeter registers correctly, proceed to step **4**). If ohmmeter readings are not correct, proceed with next step.

3) Turn engine OFF and set clearance between throttle valve shaft lever and stopper screw to .020" (.5 mm) on 280ZX and 810 or .012" (.3 mm) on 200SX. Adjust throttle switch position until ohmmeter reading goes from 0 ohms to infinity. If switch does not perform as described, replace throttle switch.

4) To check full throttle contact, disconnect negative battery cable and throttle valve switch connector. Connect ohmmeter between terminals 24 and 30. Continuity should not exist when throttle valve is in idle position. Depress accelerator to full throttle position. Continuity should exist between terminals. If not, replace throttle switch.

Fiat – 1) Before adjusting throttle valve switch, ensure engine idle speed is set to specifications. With engine OFF, remove connector from throttle switch, loosen 2 screws and connect an ohmmeter between terminals 18 (center) and 2 (right of center).

2) Rotate switch clockwise until ohmmeter reading is 0 ohms. Tighten mounting screws at point ohmmeter reading registers 0 ohms. If throttle valve switch cannot be adjusted as described, replace switch.

NOTE – *Adjustment procedures not available for Porsche or VW.*

Toyota – 1) Construct an angle gauge as shown in *Fig. 8*. Insert in throttle valve to obtain either a 55° or a 65° throttle angle. Check continuity between each terminal of switch (IDL-TL, IDL-PSW and PSW-TL).

2) At 55° throttle opening, there should be no continuity between any terminals. And at 65° throttle opening, there should be continuity between PSW and TL terminals only. If incorrect, proceed to step **3**).

3) To adjust switch, loosen adjustment screws and insert a .020" (.52 mm) feeler gauge between throttle stop screw and lever. Connect ohmmeter to terminals IDL and TL (ohmmeter should show continuity). Gradually turn switch assembly counterclockwise until ohmmeter deflects and tighten screws. Remove feeler gauge.

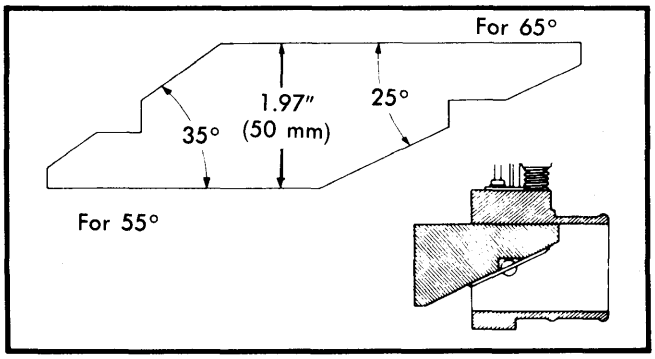

Fig. 8 Angle Gauge Dimensions for Adjusting Toyota Throttle Valve Switch

4) To recheck, insert a .017" (.44 mm) feeler gauge between throttle stop and lever. Ohmmeter should show continuity. Now, replace this feeler gauge with one that is .026" (.66 mm) and check continuity. There should be no continuity.

THROTTLE VALVE (JAGUAR ONLY)

1) Remove air intake hose and elbow to expose throttle valve. Loosen throttle valve lock nut on stop screw and loosen stop screw. Ensure throttle valve fully closes.

2) Insert .002" (.05 mm) feeler gauge between throttle valve and throttle housing bore. See *Fig. 9*. With feeler gauge in position, adjust stop screw so it just touches stop arm. Tighten locknut. Press stop arm against stop screw and remove feeler gauge.

3) Seal threads of adjusting screws and lock nuts with paint spots. Install hose and elbow. Check operation of throttle linkage and adjust if required.

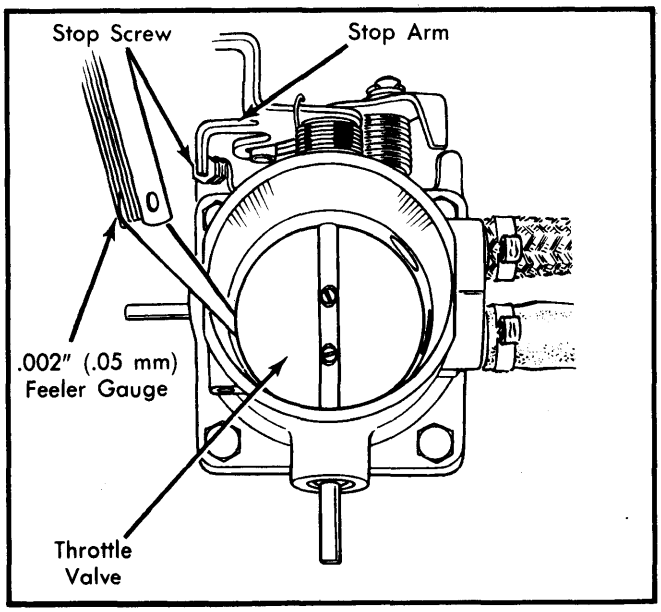

Fig. 9 Adjusting Throttle Valve Clearance (Jaguar Models Only)

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

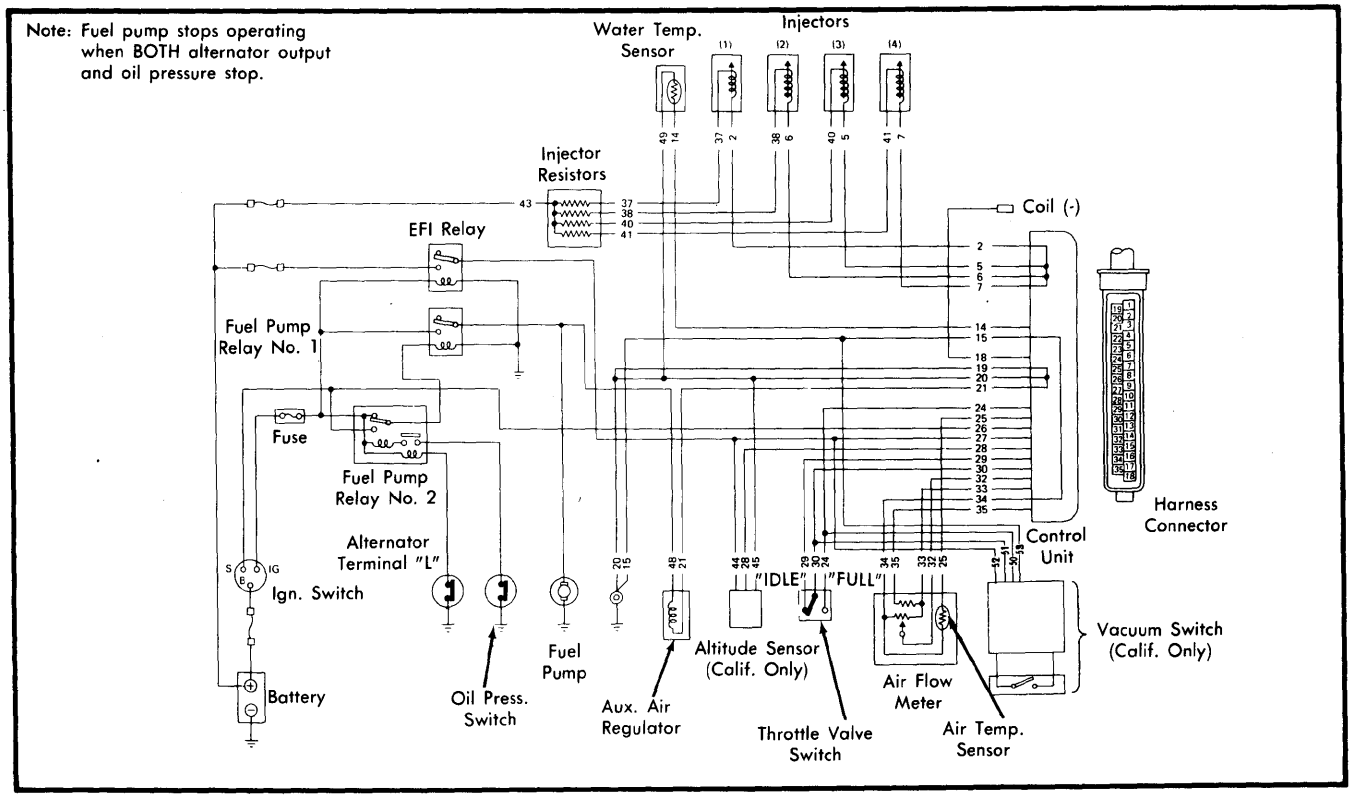

Fig. 10 Electronic Fuel Injection Wiring Diagram (Datsun 200SX)

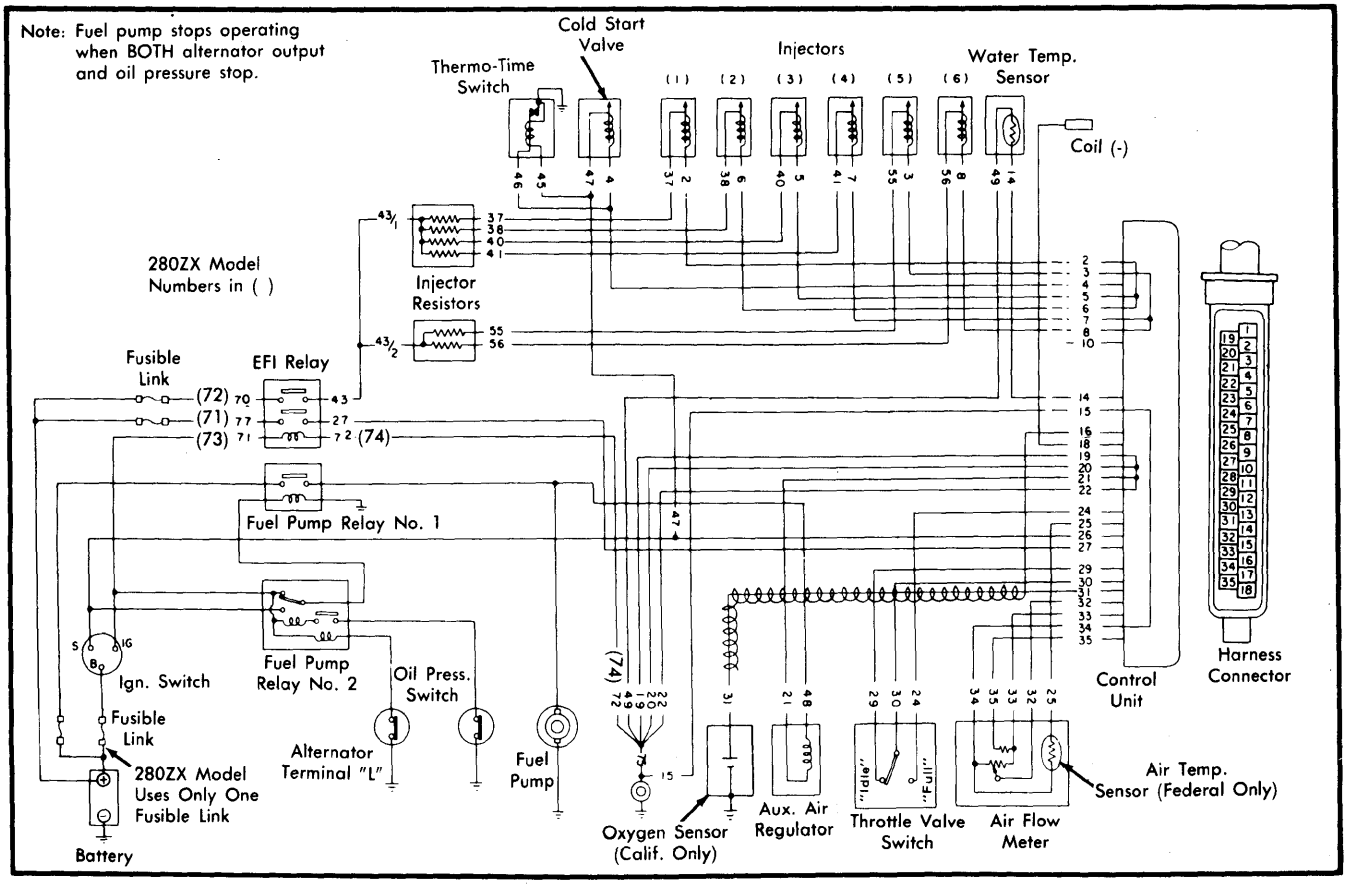

Fig. 11 Electronic Fuel Injection Wiring Diagram (Datsun 280ZX & 810)

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

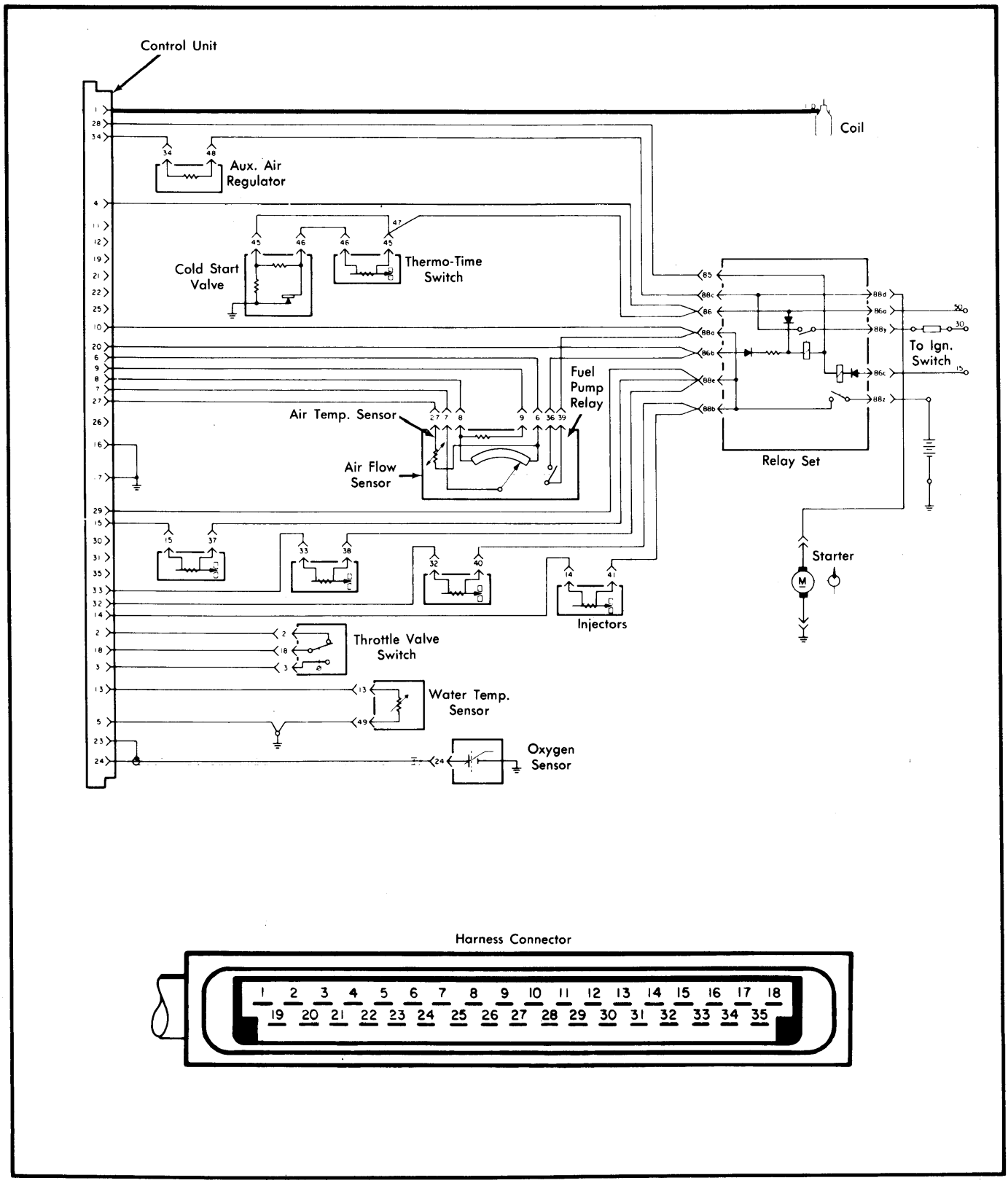

Fig. 12 Electronic Fuel Injection Wiring Diagram (Fiat Models)

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

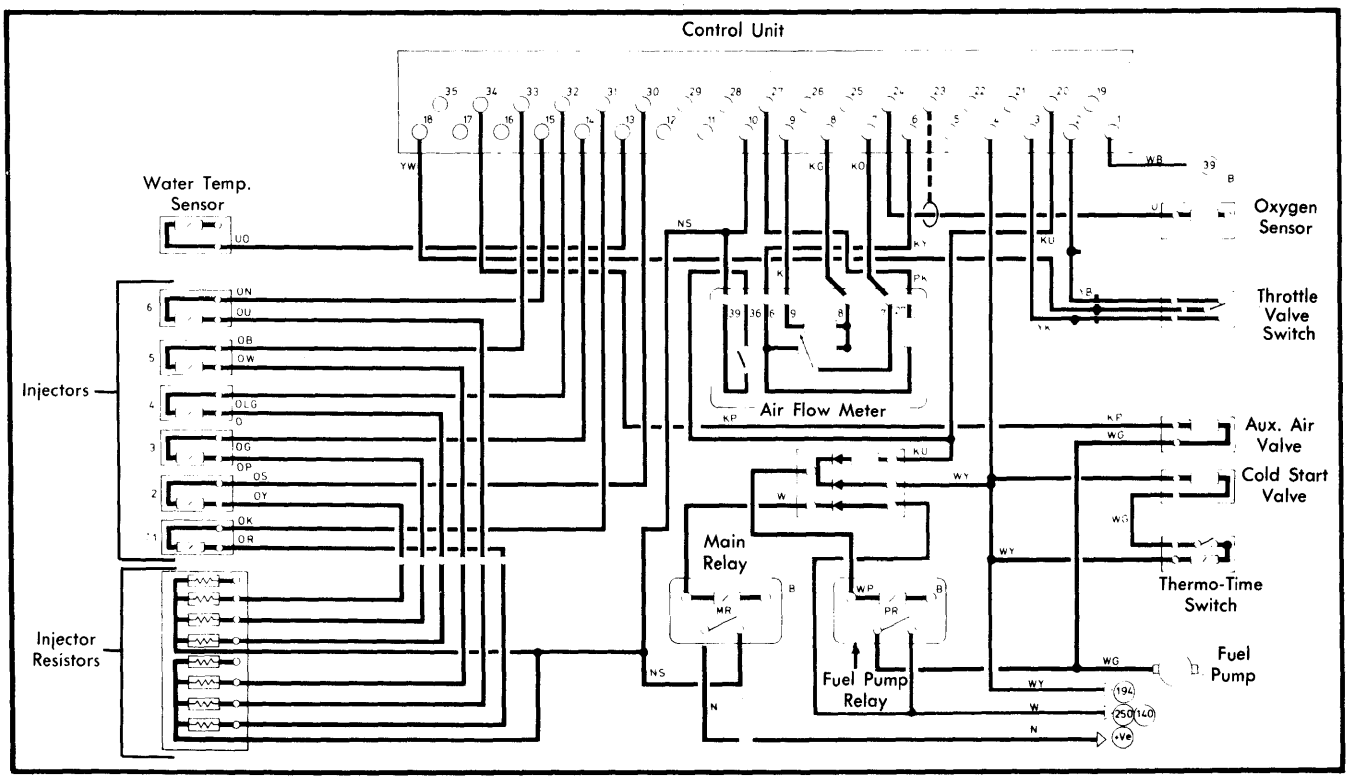

Fig. 13 Electronic Fuel Injection Wiring Diagram (Jaguar XJ6L)

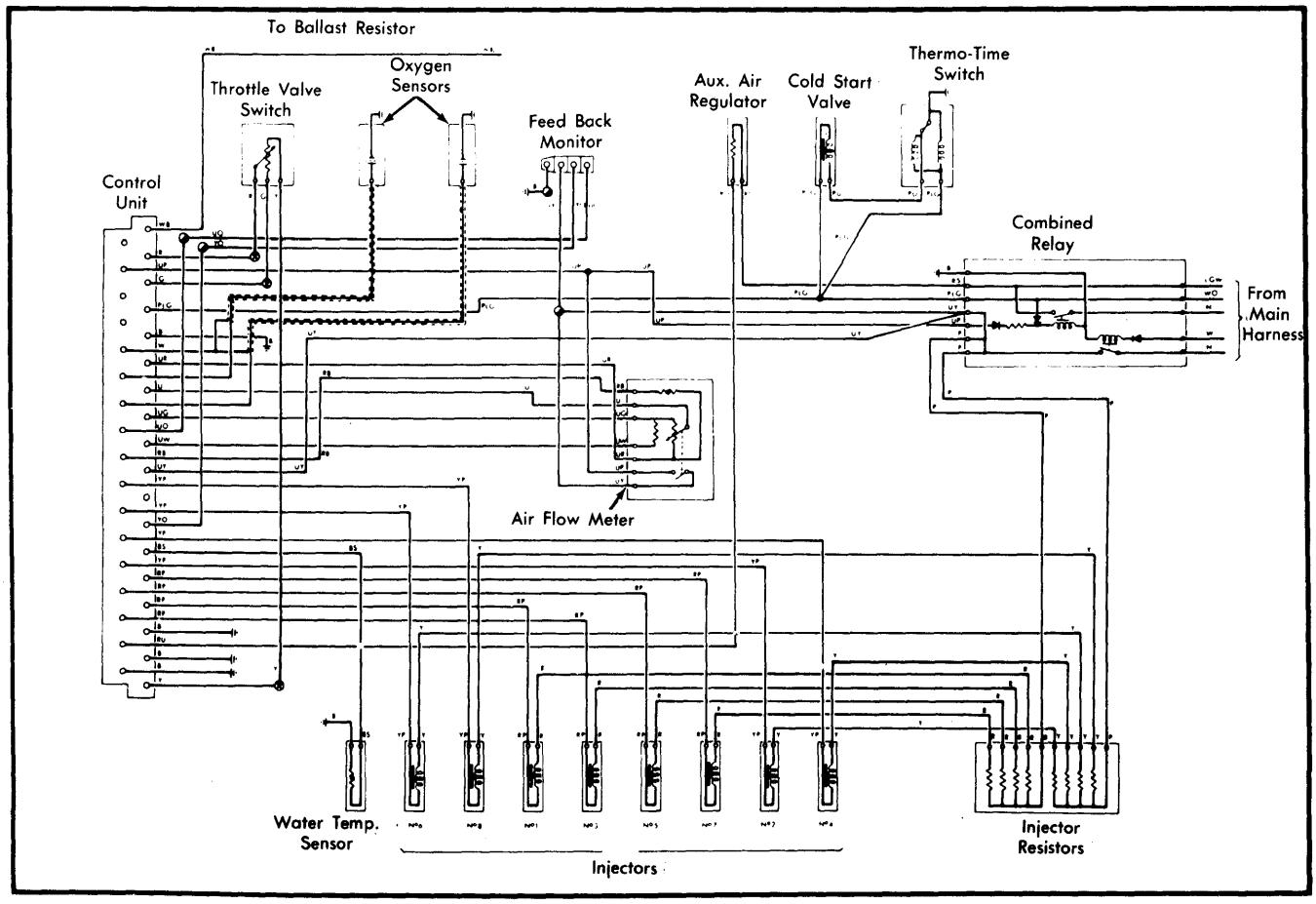

Fig. 14 Electronic Fuel Injection Wiring Diagram (TR8)

BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

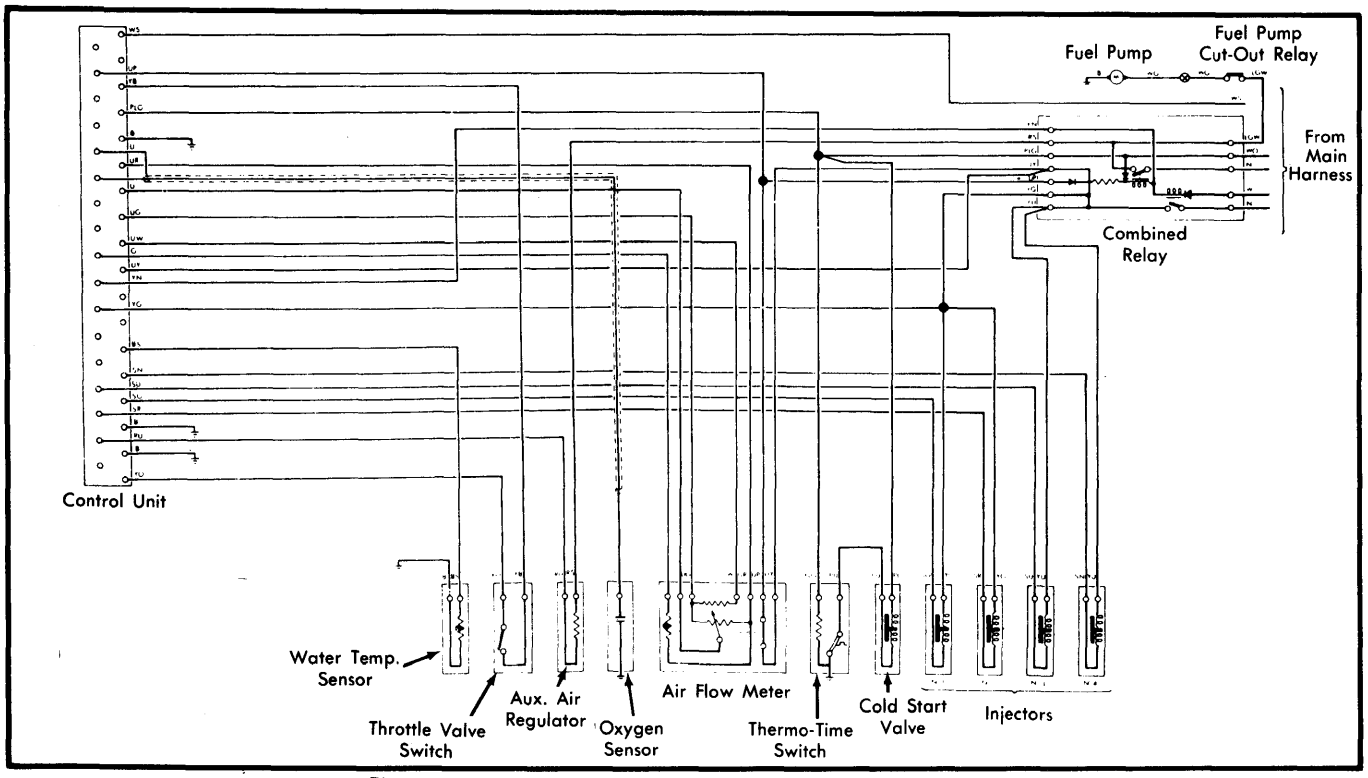

Fig. 15 Electronic Fuel Injection Wiring Diagram (TR7)

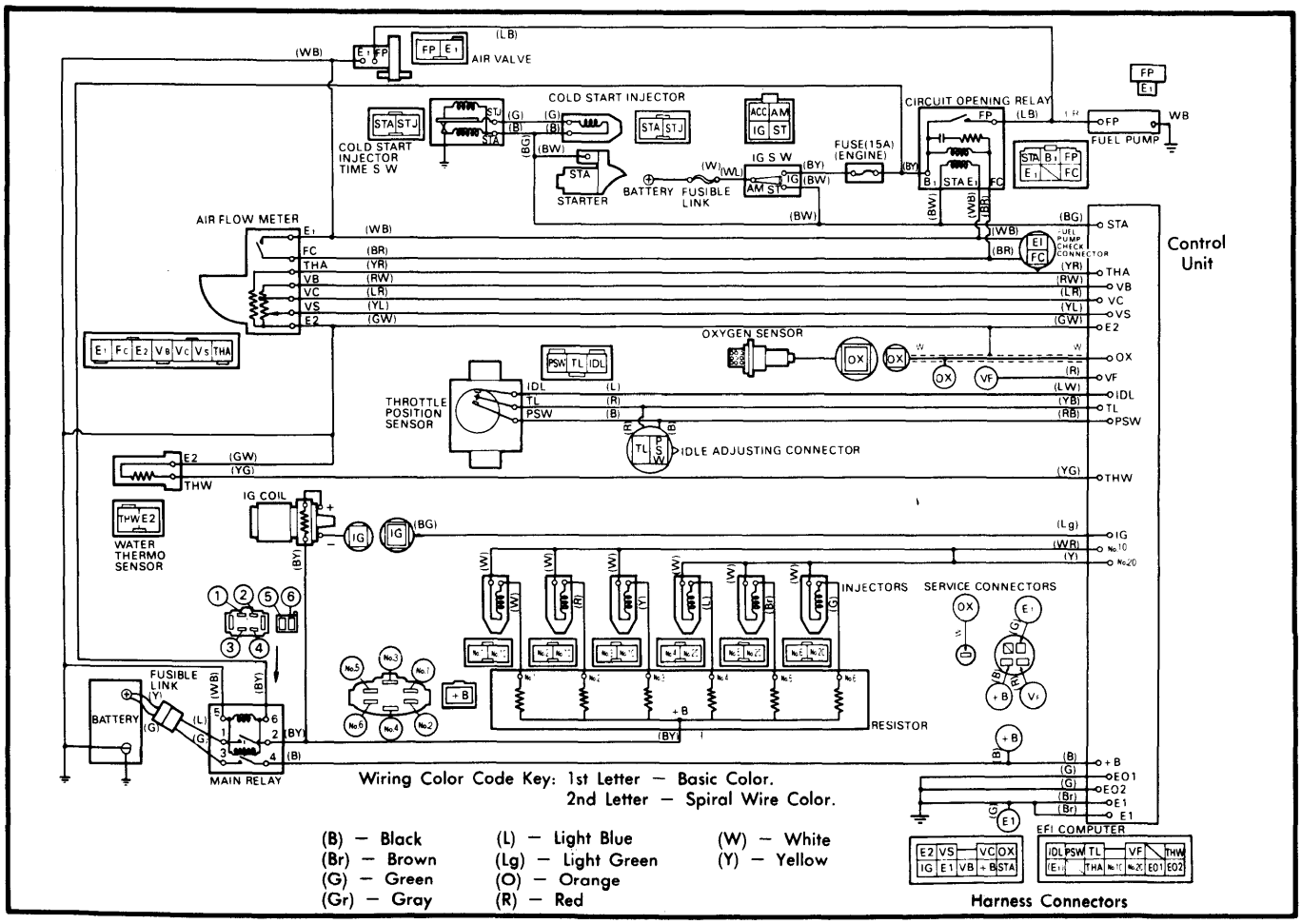

Fig. 16 Electronic Fuel Injection Wiring Diagram (Toyota Celica & Cressida)