

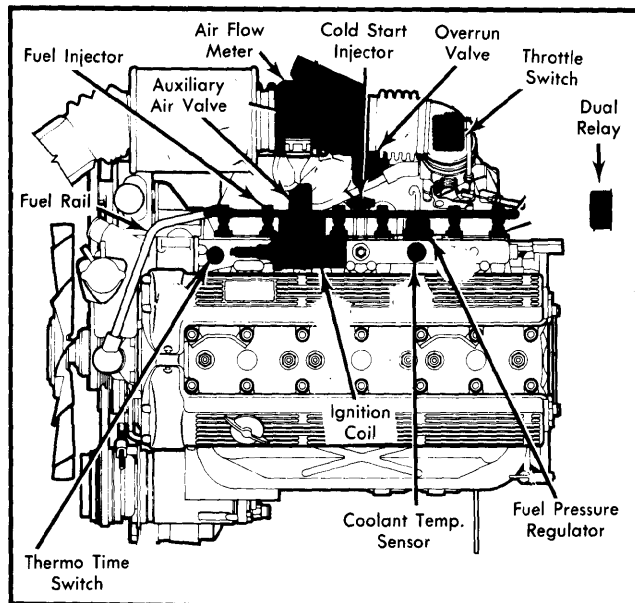
## LUCAS-BOSCH AFC FUEL INJECTION SYSTEM

**Jaguar**  
**XJ6L**  
**Triumph**  
**TR7**  
**TR8**

**NOTE** — The Lucas-Bosch AFC Fuel Injection system is used on all models. Variations may exist between model applications with the addition of auxiliary control systems. This article covers the Lucas-Bosch AFC system in general, with manufacturer's differences noted.

### DESCRIPTION

The Lucas-Bosch Air Flow Controlled (AFC) fuel injection system is an electronically controlled system operated by incoming air flow. The AFC fuel injection system also contains a feedback system which measures oxygen content of exhaust gases and maintains the air/fuel ratio at about 14.7:1. The system consists of an electric fuel pump, fuel pressure regulator, fuel injectors, Electronic Control Unit (ECU), air flow meter, air temperature sensor, throttle switch, coolant temperature sensor, oxygen sensor (2 on TR8), 3-way catalytic converter and electrical relays. In addition, all models are equipped with a cold start system to aid in cold engine starts. The cold start system consists of an auxiliary air valve, cold start injector and thermo time switch.



**Fig. 1 Jaguar AFC Fuel Injection System**

### OPERATION

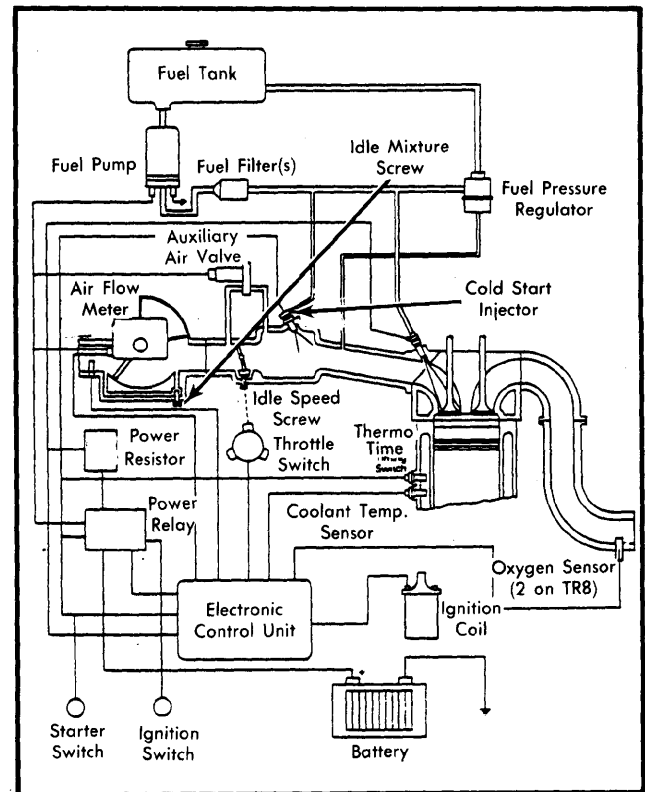
#### ELECTRIC FUEL PUMP

The fuel pump provides fuel under pressure to the fuel pressure regulator. Power for operation during cranking mode is provided from starter relay via the electrical relay. After the engine has started, control of the fuel pump is by a fuel pump circuit in the air flow meter. The first movement of air flow meter air measuring flap (about 5°) closes the fuel pump contacts and provides power to fuel pump after engine has started. With engine stopped, no air flow is present, measuring

flap closes and fuel pump contacts are opened to cut power to fuel pump. This method of circuitry reduces the risk of fire in a collision. The fuel pump is a sealed unit; no service required.

#### FUEL PRESSURE REGULATOR

The pressure regulator consists of a sealed, spring loaded diaphragm with a connection for intake manifold vacuum. Fuel is provided to fuel injectors under 36 psi (2.5 kg/cm<sup>2</sup>) pressure. A connection for intake manifold vacuum provides a constant pressure differential which ensures that the amount of fuel injected is solely dependent upon injector "open" time. Fuel in excess of fuel pressure or pressure differential is returned to fuel tank. No service of pressure regulator is required.



**Fig. 2 Triumph AFC Fuel Injection System**

#### FUEL INJECTORS

A fuel rail links the fuel pressure regulator with the fuel injectors. Each cylinder is provided with a solenoid-operated injector which sprays fuel towards back of each inlet valve. Each injector is energized through the ignition coil and grounded through the ECU to complete the circuit.

Each injector is linked to a resistor to reduce operating voltage to 3 volts and to protect injectors from power surges (except TR7 models). Resistors for Jaguar models are located in a single unit mounted on right side of firewall; TR8 resistors are located between ECU and injectors.

The ECU controls the length of time each injector is open. The "open" time of the injector governs the amount of fuel delivered. The injectors deliver 1/2 the amount of fuel required for 1 operating cycle each time they spray (twice per cycle).

## LUCAS-BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

## ELECTRONIC CONTROL UNIT (ECU)

All components of the control system are electrically connected to the ECU. 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 efficiency with minimum exhaust emissions. Impulses from the oxygen sensor(s) informs the ECU of oxygen content of exhaust gases and the ECU constantly adjusts the air/fuel ratio by controlling the injector "open" time.

The ECU provides 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. The ECU is a sealed unit; no service is required.

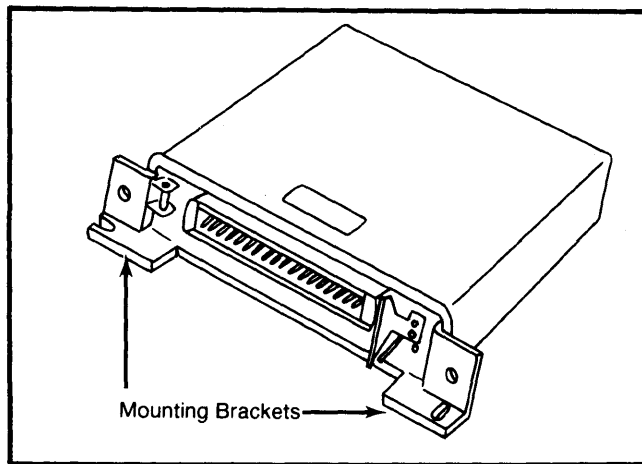


Fig. 3 Electronic Control Unit (ECU)

## AIR FLOW METER

All engine air is drawn through the air flow meter. The meter is basically a tunnel with 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 and is connected to a potentiometer. The potentiometer transmits an electrical signal proportionate to the angular displacement of the measuring flap to inform the ECU of engine load. See Fig. 4.

In addition to monitoring air flow, the meter also controls fuel pump operation and idling. At idle, the measuring flap is almost closed due to spiral spring pressure. An idle air by-pass receives air from main air flow through a small hole, the size of which is controlled by the idle mixture screw. This adjustable air by-pass influences CO levels at low engine speeds.

## AIR TEMPERATURE SENSOR

The air temperature sensor is an integral component of the air flow meter which converts the temperature of incoming air into electrical signals. These electrical signals are received by the ECU and processed to adjust the amount of fuel injected by the injectors. The air temperature sensor is a non-serviceable device.

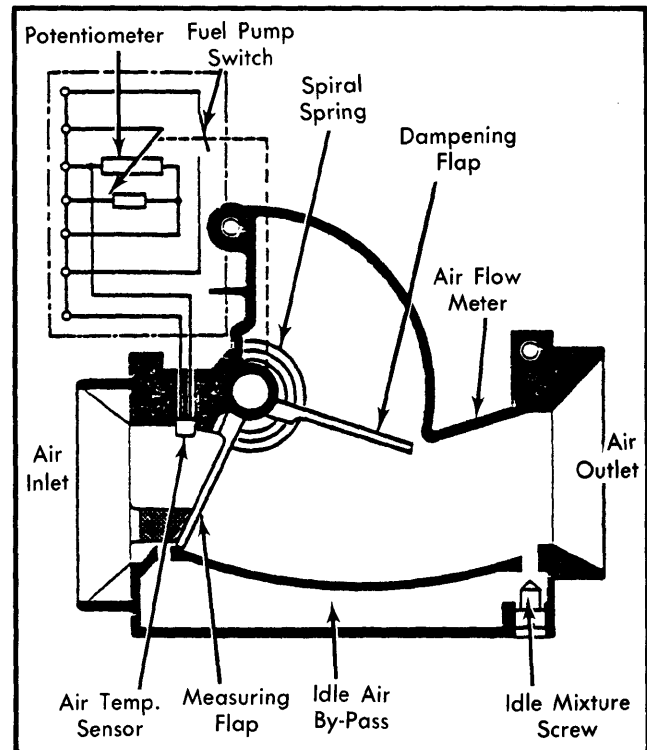


Fig. 4 Lucas-Bosch AFC Air Flow Meter

## THROTTLE 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 information on throttle position to ECU. On contact switch, signals are sent when throttle is at idle or full throttle positions. See Fig. 5. The potentiometer switch monitors the throttle valve angle and an electrical signal proportionate to throttle position is sent to ECU.

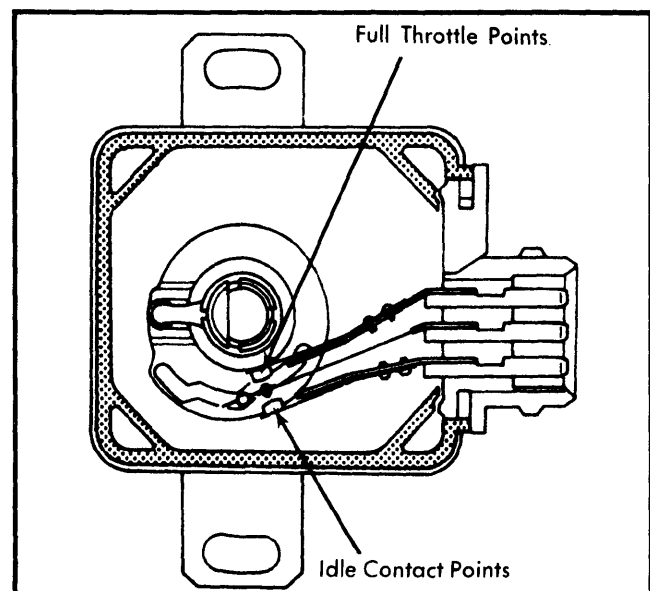


Fig. 5 Contact Type Throttle Switch

## LUCAS-BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

### COOLANT TEMPERATURE SENSOR

This sensor provides ECU with engine temperature information relating to warm-up enrichment operation. During warm-up period after a cold engine start, additional fuel is required to maintain engine performance. As coolant temperature increases, the ECU decreases fuel enrichment until engine reaches normal operating temperature.

### ELECTRICAL RELAYS

The main (double) relay activates the ECU, injector circuit and starting circuit when ignition is switched to start mode. The fuel pump relay activates the fuel pump during start mode. It is then controlled by air flow during operating mode. Relay for Jaguar models is located in engine compartment, near battery. On all other models, it is located in passenger compartment, behind the glove compartment.

### COLD START SYSTEM

The cold start system provides additional air and fuel during cold engine starts. The cold start system consists of an auxiliary air valve which provides additional air, cold start injector which delivers additional fuel and a thermo time switch which controls operation of the cold start system. The thermo time switch has a bi-metal contact surrounded by a heating coil which is energized during engine cranking. This switch limits cold start system to 5-12 seconds under extreme cold engine starts in relation to engine coolant temperature. When coolant temperature is above 95°F (35°C), bi-metal contact breaks ground circuit of cold start injector and cold start enrichment is by-passed.

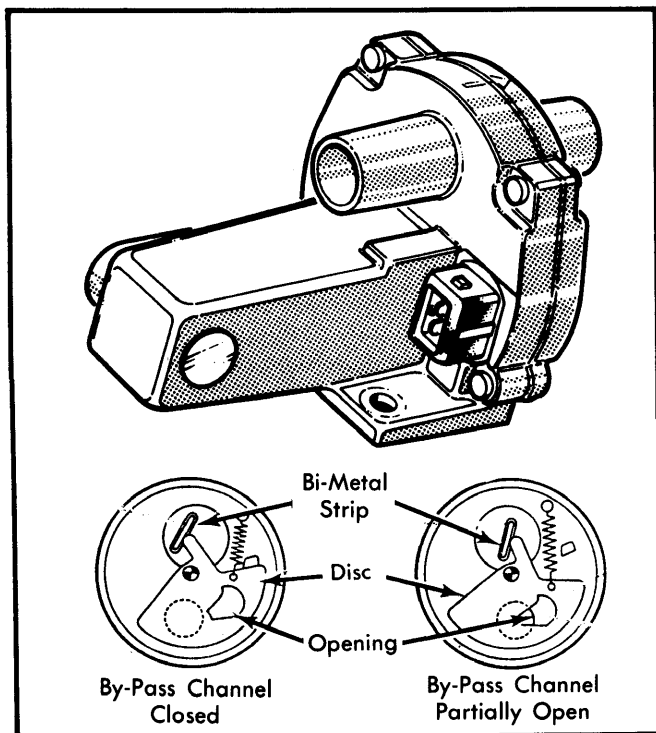


Fig. 6 Auxiliary Air Valve

The auxiliary air valve provides additional air during cold engine starts and warm-up period. The valve consists of an

electrically heated bi-metal strip, movable disc and air by-pass channel. The heater coil on the bi-metal strip is energized by the fuel pump relay. Control of the valve is based upon engine temperature; the air by-pass channel is open when engine is cold and gradually closes as temperature rises. At predetermined temperatures, air by-pass channel is blocked and additional air flow stops. See Fig. 6.

### TESTING

**NOTE** — The Lucas-Bosch AFC fuel injection system maintains constant fuel pressure in fuel lines and components 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, or allow an open flame in area while testing fuel system or components.

### ELECTRONIC CONTROL UNIT (ECU)

Do not attempt to test ECU, permanent damage could result. It is possible to check plug wires for continuity. The ECU should only be judged faulty after compression is checked, 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

- 1) Depressurize fuel system by disconnecting fuel pump ground lead and cranking engine for a few seconds. Turn ignition switch off and reconnect fuel pump ground lead. Disconnect fuel rail at cold start injector and connect fuel pressure gauge.
- 2) Disconnect negative lead from ignition coil and turn ignition switch on. Pressure reading should be 35.5-37 psi (2.5-2.6 kg/cm<sup>2</sup>). Slow pressure drop is permissible; sudden pressure drop requires check of entire fuel system for leaks. After testing fuel pressure, depressurize fuel system, remove test equipment and reconnect fuel lines and ignition coil negative lead.
- 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.

### FEEDBACK MONITORING SYSTEM (TRIUMPH MODELS ONLY)

- 1) Start and run engine until normal operating temperature is obtained. If engine is already hot, run engine for 2 minutes before testing. Connect feedback monitor (60973066) to diagnostic connector in harness near ECU. Place feedback monitor switch in "LOW" position. See Fig. 7.
- 2) Mixture is correct when either No. 2 or No. 3 lights in either row glows. Any other light combination, except No. 1 or No. 4 lights in either row, is acceptable.
- 3) If both No. 3 lights glow, remove mixture screw plug and adjust mixture until No. 2 and No. 3 lights in either row glow. Turning mixture screw clockwise richens mixture, counter-clockwise leans mixture.

## LUCAS-BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

4) After setting mixture, remove vacuum pipe from fuel pressure regulator with feedback monitor still connected. Lights should move to left, indicating richer mixture (for example, from No. 2 to No. 1). If lights do not shift, check wiring circuit and/or replace oxygen sensor.

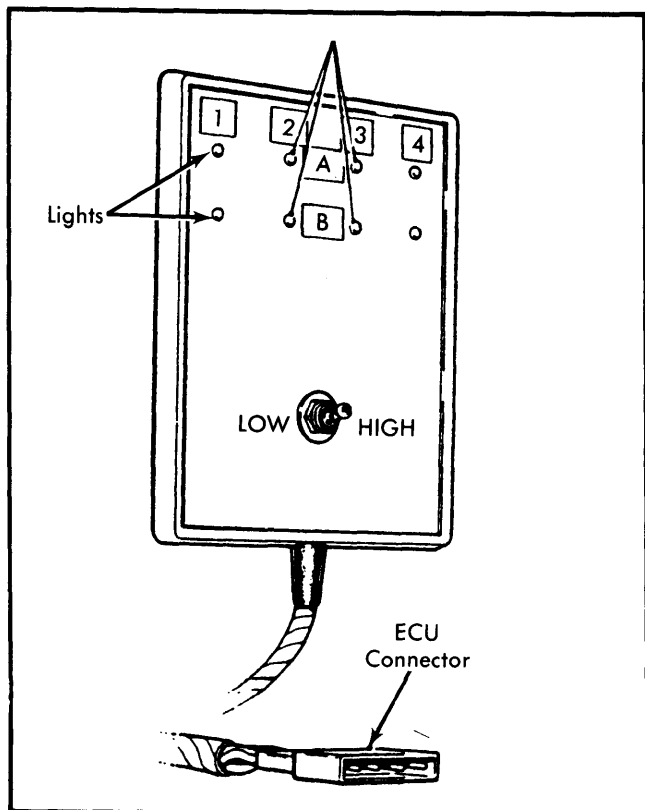


Fig. 7 Triumph Feedback Monitor

## AIR TEMPERATURE SENSOR

Disconnect negative battery strap and air flow meter connector. Connect ohmmeter leads to terminals 6 and 27 on potentiometer connector. Readings should be as shown in Temperature/Resistance Relationship chart. If not, replace temperature sensor and air flow meter as an assembly.

Temperature/Resistance Relationship	
Temperature	Resistance (Ohms)
14°F (-10°C)	9200
32°F (0°C)	5900
68°F (20°C)	2500
104°F (40°C)	1180
140°F (60°C)	600

## AUXILIARY AIR VALVE

1) Remove auxiliary air valve connector and connect an ohmmeter to both terminals. Resistance should read approximately 33 ohms. If not, continue testing as follows:

2) Remove auxiliary air 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 by-pass channel. Gradually heat water; as temperature increases, channel should become blocked. If valve does not respond as outlined, replace auxiliary air valve.

## THERMO TIME SWITCH

1) Using a thermometer, check engine coolant temperature. Compare coolant temperature with value stamped on thermo time switch body. Connect an ohmmeter between terminal "W" on switch and ground.

2) If coolant temperature is higher than switch value, a very high resistance denoting an open circuit should be obtained. If coolant temperature is lower than switch value, a very low resistance denoting a closed circuit should be obtained. If switch does not respond as outlined, replace thermo time switch.

3) If switch passes resistance test, allow coolant temperature to cool below stamped value on switch. With ohmmeter connected, connect battery power via an isolating switch to terminal "G". Using a stop watch, check delay time as ohmmeter changes between high and low resistance. Delay period should be as shown in Coolant/Delay Time Relationship chart. If not, replace thermo time switch.

## Coolant/Delay Time Relationship

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

## COLD START INJECTOR

1) Remove electrical connector from cold start injector and connect voltmeter across connector terminals. Crank engine with ignition switch. Battery voltage should be present.

2) Release fuel system pressure and remove cold start injector with fuel lines attached. Reconnect electrical connector and place injector in container. As cold engine is cranked with ignition switch, fuel spray should be observed until thermo time switch cuts off relay. When engine is warm, no fuel spray should occur during cranking. If injector does not respond as outlined, replace cold start injector.

## COOLANT TEMPERATURE SENSOR

Disconnect battery ground cable and electrical connector from sensor. Connect an ohmmeter between sensor terminals. Reading should be as shown in Temperature/Resistance Relationship chart. Disconnect ohmmeter and check resistance between each terminal and sensor body. A very high resistance denoting an open circuit should be obtained. If sensor does not respond as outlined, replace coolant temperature sensor.

## LUCAS-BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

### Temperature/Resistance Relationship

Temperature (Coolant)	Resistance (Ohms)
14°F (-10°C) .....	9200
32°F (0°C) .....	5900
68°F (20°C) .....	2500
104°F (40°C) .....	1180
140°F (60°C) .....	600
176°F (80°C) .....	325

### THROTTLE SWITCH (JAGUAR & TR7 MODELS ONLY)

Disconnect battery ground cable and throttle switch electrical connector. Connect a powered test lamp between terminals 3 and 18 of throttle switch. Open throttle; test lamp should glow when throttle nears wide open position. If not, replace throttle switch.

## REMOVAL & INSTALLATION

### AIR FLOW METER

**Removal & Installation** — Disconnect battery ground cable. Disconnect rubber hose from both sides of air flow meter. Disconnect air flow meter ground cable and remove bolts securing meter to bracket. Move air flow meter upward, disconnect electrical connector and remove air flow meter. To install, reverse removal procedure.

### ELECTRONIC CONTROL UNIT (ECU)

**Removal** — Disconnect battery ground 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, retaining band and cable clamp clip. Unclip end cover and lift out ECU. Disconnect pin connector and remove ECU.

**Installation** — To install, reverse removal procedure, making sure pin connector is installed squarely and securely.

### COLD START INJECTOR

**Removal & Installation** — Disconnect battery ground cable and remove electrical connector from injector. Release fuel line pressure. Remove injector retaining screws and remove injector. To install, reverse removal procedure.

### AUXILIARY AIR VALVE

**CAUTION** — Auxiliary air valve removal should be done only when engine is cold. Removal of valve requires having replacement valve ready for immediate installation or draining cooling system below level of valve.

**Removal & Installation** — Disconnect battery ground cable. Disconnect air hoses and electrical connector from auxiliary air valve. Remove coolant system cap. Remove valve retaining bolts and air valve. Clean all gasket material from mating surfaces without damaging seating area. To install, coat new gasket with non-hardening sealing compound and reverse removal procedure.

### COOLANT TEMPERATURE SENSOR

**CAUTION** — Coolant temperature sensor removal 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 & Installation** — Disconnect battery ground cable. Drain coolant and disconnect sensor electrical connector. Loosen and remove sensor. To install, reverse removal procedure using suitable sealing compound on sensor threads. Replace sealing washers, if equipped.

### THERMO TIME SWITCH

**CAUTION** — 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 & Installation** — Disconnect battery ground cable. Drain coolant and disconnect switch electrical connector. Loosen and remove switch. To install, reverse removal procedure using suitable sealing compound on switch threads.

### FUEL PRESSURE REGULATOR

**CAUTION** — Fuel system pressure must be relieved before removing fuel pressure regulator.

**Removal & Installation** — Disconnect battery ground cable. Disconnect fuel lines and vacuum line at regulator. Remove pressure regulator (separating from bracket, if installed). To install, reverse removal procedure.

### FUEL INJECTORS

**CAUTION** — Fuel system pressure must be relieved before removing fuel injectors.

**Removal** — 1) Disconnect battery ground cable. Disconnect electrical connectors at injectors. Remove screws attaching fuel rail to intake manifold. Release clips holding fuel supply and return rails.

2) Remove manifold pressure pipe. Remove nuts and washers from injector clamps. On Jaguar models, lift off fuel rail with injectors, loosen injector clamps and remove injectors from fuel rail. Remove and discard "O" rings if equipped. On Triumph models, remove fuel rail and unscrew injectors.

**Installation** — To install, reverse removal procedure, making sure electrical connectors are properly installed on injectors before installing fuel rail assembly to manifold and new "O" rings are installed on injectors, if equipped.

## ADJUSTMENTS

### HOT (SLOW) IDLE RPM

See appropriate article in TUNE-UP section.

### IDLE MIXTURE

See appropriate article in TUNE-UP section.

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## LUCAS-BOSCH AFC FUEL INJECTION SYSTEM (Cont.)

### THROTTLE SWITCH (TR8 ONLY)

Disconnect electrical connector at throttle switch and connect throttle tester (60973067) to switch. With engine at normal operating temperature and idle speed set to specifications, adjust throttle switch until green light on tester glows. Remove tester and reconnect electrical connector.

### 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 closes fully.
- 2) Insert a .002" (.05 mm) feeler gauge between throttle valve and throttle housing bore. See Fig. 8. With feeler gauge in position, adjust stop screw so it just touches stop arm. Tighten lock nut. 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 by ensuring outer cable is secured in bracket so inner cable is under light tension, but not enough to move operating lever. Tighten lock nuts.

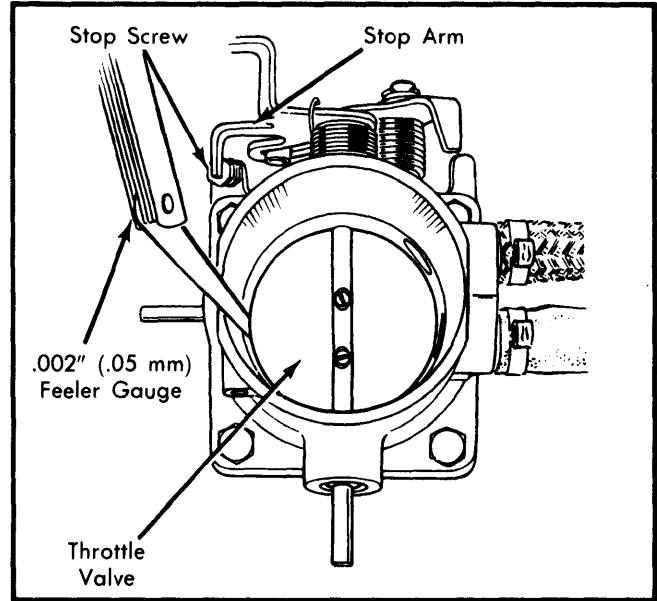


Fig. 8 Adjusting Jaguar Throttle Valve Clearance

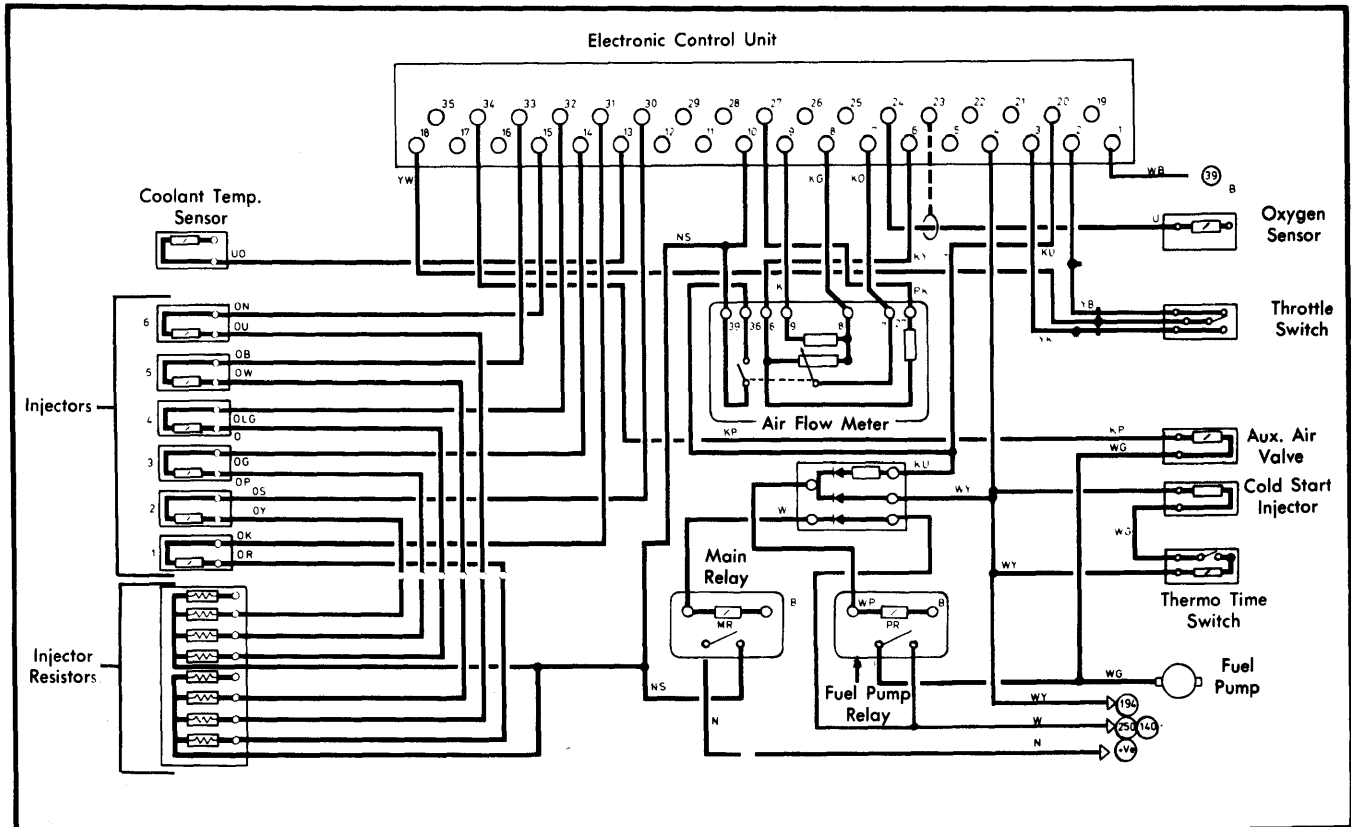
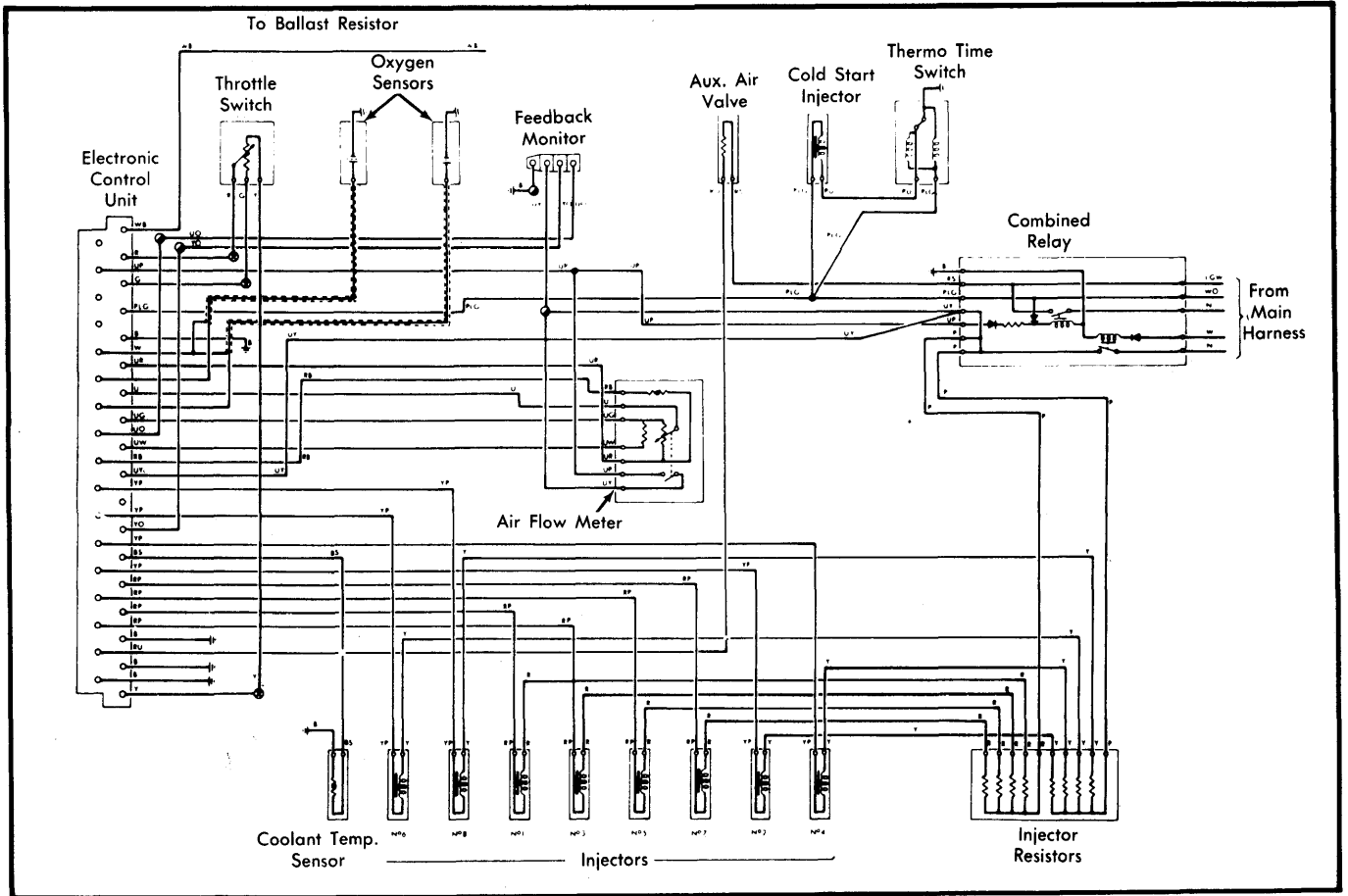
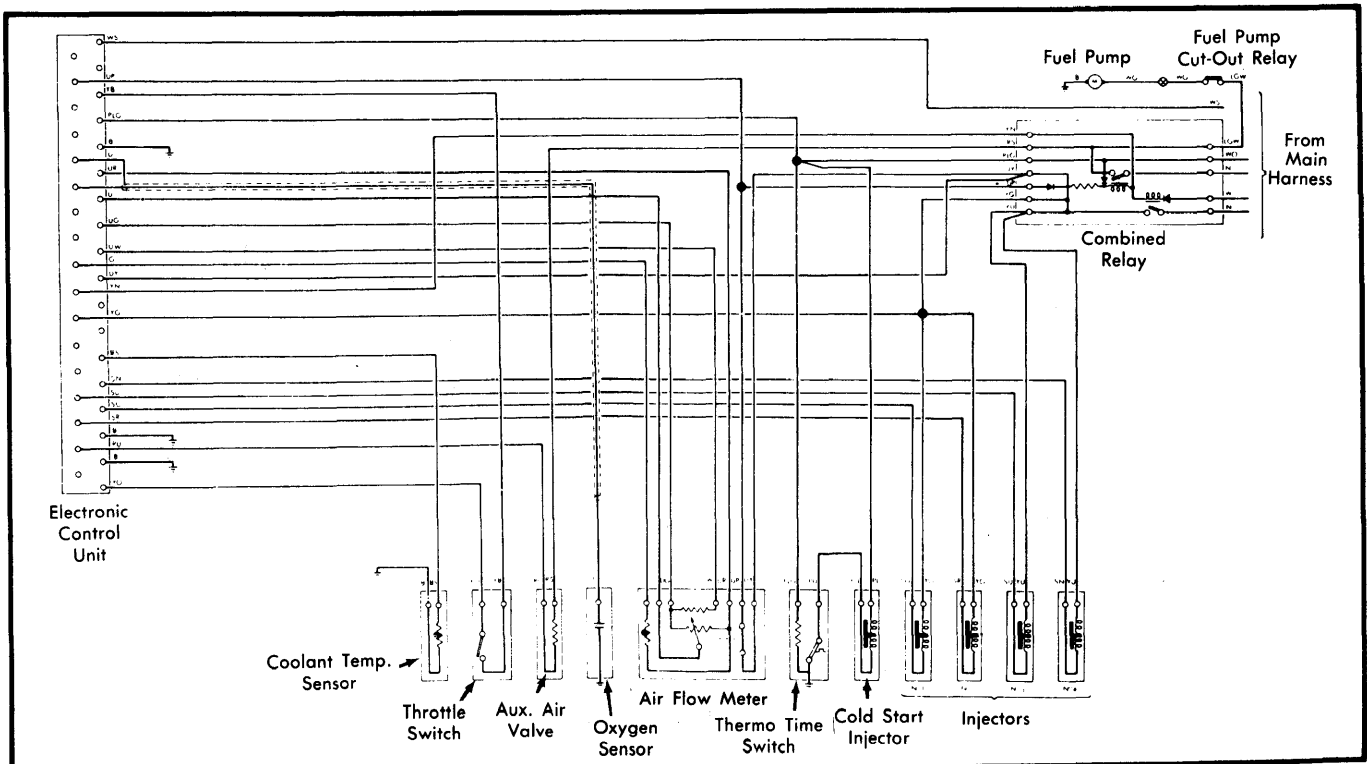


Fig. 9 Jaguar XJ6L Fuel Injection Wiring Diagram

## LUCAS-BOSCH AFC FUEL INJECTION SYSTEM (Cont.)



**Fig. 10 Triumph TR8 Fuel Injection Wiring Diagram**



**Fig. 11 Triumph TR7 Fuel Injection Wiring Diagram**