DEMYSTIFYING THE PORSCHE 914'S BOSCH D-JETRONIC

FUEL INJECTION SYSTEM

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Introduction -

In the late 1960s, several European automobile manufacturers began incorporating electronic fuel injection systems into their products. The advantages of these systems over carburetion included higher reliability, wider range of operating conditions (altitude, etc.) better fuel economy and lower emissions. One of the first such systems generally available was the Robert Bosch "D-Jetronic" system which senses the difference between the air pressure in the intake manifold and normal atmospheric pressure, and uses this pressure difference along with other engine operating parameters to precisely control the length of time the injector valves remain open and consequently the amount of fuel injected into the cylinders.

By the time production of the Porsche 914 began, Volkswagen had two years' experience with D-Jetronic in the Type 3 VW Squareback. The D-Jetronic, or "MPC" (for Manifold Pressure Control), system was used in the 1.7 liter and 2.0 liter 914s. The 1.8 liter 914 used the significantly different L-Jetronic, or "AFC" (for Air Flow Control) system.

The system described in this article is the D-Jetronic system used in the 1.7 and 2.0 liter cars.

Theory of Operation -

The D-Jetronic system consists of the following three basic components:

- Fuel System - Devices responsible for the delivery, pressure generation, pressure regulation, and cleaning of fuel, as well as injection of fuel into each cylinder

- Detecting Elements - Devices which sense and collect all engine operating data necessary for calculating precise fuel requirements at any given instant for all operating conditions

- Electronic Control Unit - The device which processes the data provided by the detecting elements and interprets these data to determine the length of time (duration) each injector valve remains open, and consequently the amount of fuel metered into each cylinder

The Fuel System -

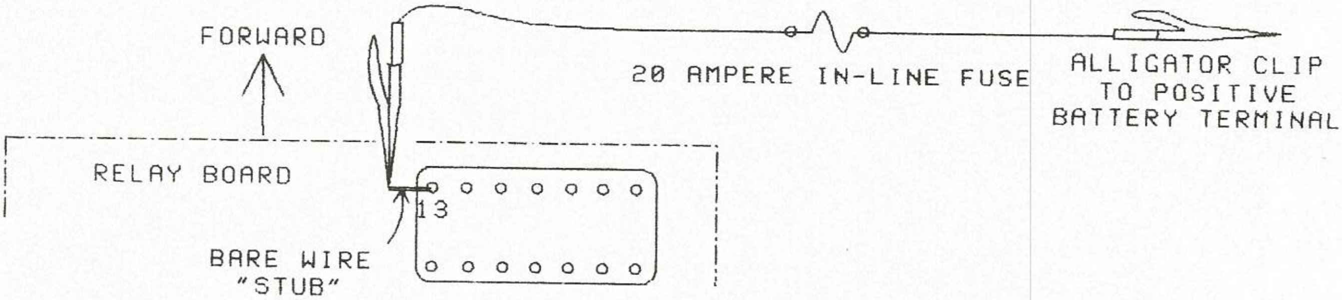
The fuel system is very straightforward and is relatively troublefree. Fuel is drawn from the tank via the fuel filter by an electric fuel pump and is forced into the ring main, a manifold which distributes the fuel to the four injector valves. A pressure regulator maintains the pressure in the ring at 28.4 psi (2 atmospheres). From the regulator, surplus fuel flows back into the tank through a pressureless line. The bypass return line coming from the fuel pump also leads into this line.

In brief, the function of the fuel system is to deliver fuel to the four fuel injectors at a steady pressure of 28.4 psi.

Common Problems with the Fuel System -

In the 914, the most common problems associated with the fuel system are interruption of power to the fuel pump and vapor lock (in pre-1975 models) due to the close proximity of the fuel pump to the exhaust manifold.

Power to the fuel pump takes a rather circuitous route through two relays (the main power relay and the fuel pump relay), a fuse, and numerous connectors on the engine compartment relay board. A failure of either of these relays, the fuse, or a poor electrical connection (dirt, corrosion, etc.) through the connectors or fuseholder will result in loss of power to the fuel pump. In any fuel injected engine, if the fuel pump fails the engine will not run. A simple way of determining whether or not power is present at the fuel pump is to listen carefully for the fuel pump to run briefly when the ignition key is first turned on, but before the starter is engaged. If a muted "buzzz" lasting one to two seconds is not heard, it is likely that power is not reaching the fuel pump. Since this problem usually manifests itself at the most inopportune times (dark and stormy nights), I have soldered a short "stub" of wire to pin 13 of the 14 pin wiring harness connector which plugs into the relay board. Pin 13 goes directly to the fuel pump motor. In an emergency, I use a three foot long jumper wire with a 20A in-line fuse and an alligator clip on each end to connect the "hot" terminal of the fuel pump motor directly to the battery by clipping one end of the jumper wire to the stub wire on pin 13, and the other end to the positive battery pole. This bypasses the relays, fuse and ECU in providing power to the fuel pump motor. **This technique should be used only in a dire emergency, and one must remember to disconnect the jumper as soon as the engine is stopped.** This jumper wire is schematically represented at the top of page 3.



The vapor lock problem usually manifests itself on hot days. The car stops and cannot be restarted until the engine cools down. This can be a very frustrating experience, and is easily remedied by relocating the fuel pump to the forward part of the car near the steering rack. This relocation was finally incorporated by the factory in 1975, but owners of the earlier models are frequently plagued by the inconvenience of unscheduled stops, and this one problem alone has been responsible for many otherwise happy 914 owners selling their cars in utter exasperation.

Detecting Elements -

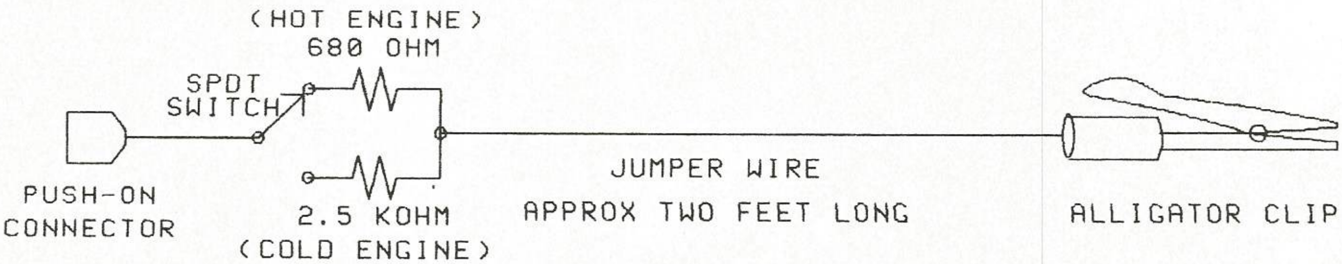
The ignition distributor used in D-Jetronic equipped 914s contains two sets of trigger contacts (spaced 180 degrees apart) which are alternately operated by a single-lobe cam on the distributer shaft. These contacts determine when and into which pair of cylinders fuel is to be injected. Cylinders 1 and 4 are "pair 1", and cylinders 3 and 2 are "pair 2". Since the fuel pressure in the ring main feeding the injectors is at a constant pressure of 28.4 psi, the quantity of fuel to be injected at any given time is controlled by the **length of time** the injectors remain open. This time period is determined primarily by the engine speed (sensed by the trigger contacts in the distributor), and the intake manifold pressure (representing engine load) which is detected by the pressure sensor.

Other sensor data such as engine temperature (detected by temperature sensor II in the cylinder head of cylinder 3), ambient air temperature (detected by temperature sensor I in the air intake distributor), and rate of acceleration or deceleration (detected by the throttle valve switch) are also evaluated by the electronic control unit (ECU) and used in calculating the duration of pulses, and consequently the amount of fuel, transmitted to the injectors.

Common Problems with the Detecting Elements -

Since the trigger contacts provide the initial pulses from which the ECU generates pulses to the injectors, dirty or defective trigger contacts can cause the engine to die immediately after starting (usually after misfiring) or misfire while driving. A defective pressure sensor can cause a variety of symptoms including loss of power, an inability to start the engine, and a situation where the engine starts, but almost immediately stops. Another sensor which can prevent starting the engine is an open temperature sensor II. A defective temperature sensor II can also cause high fuel consumption.

Temperature sensor II, the cylinder head sensor, has been known to fail intermittently in one or the other of its two failure modes ("open" and "shorted"). Since this sensor is a "negative temperature coefficient" thermistor, its resistance varies inversely with the temperature of the cylinder head. In other words, when the engine is hot, the resistance of the sensor is lower than when the engine is cold. In practice, the resistance of the sensor is about 680 ohms when the engine is at operating temperature, and about 2,500 ohms at 68 degrees F. If the sensor "opens up" (effectively infinite resistance), the ECU thinks the engine is **very cold** and provides a much longer pulse to the injectors, usually resulting in a flooded engine. If, on the other hand, the sensor "shorts out", the injector pulse width is extremely short resulting in a lack of sufficient fuel for the engine to run. A simple device consisting of a male "push-on" connector, two resistors, a SPDT toggle switch, jumper wire and alligator clip may be used to bypass a defective temperature sensor II in an emergency. This device is schematically represented below.



REPLACE PUSH-ON CONNECTOR FROM TEMP SENSOR II WITH PUSH-ON CONNECTOR. CONNECT ALLIGATOR CLIP TO GOOD CHASSIS GROUND. SWITCH TO 680 OHM OR 2.5 KOHM RESISTER DEPENDING ON WHETHER ENGINE IS HOT OR COLD.

If the throttle valve switch is defective or incorrectly adjusted, engine idle speed may be unstable or incorrect. It is easily adjusted with an ohmmeter.

<u>Electronic Control Unit</u> -

The ECU analyzes inputs from all the detection devices and generates pulses of precise duration (between 2 and 10 milliseconds) which open the fuel injectors for the appropriate period of time. The most important components in the unit are both output stages (pair 1 and pair 2) known as the switching logic and timing stages. Also located in the

ECU are correcting stages for warm-up enrichment, engine speed, and acceleration enrichment. The pressure sensor and both trigger points in the distributor connect directly to the timing stage. These ECU components determine fuel quantity.

The engine speed sensor, working in conjunction with the fuel cutoff function and throttle valve switch, effects a complete cutoff of the fuel supply on overrun deceleration (only for 914 1.7 liter until August 1971). In addition, the control unit has an overflow cutoff which ensures that the fuel pump runs only when the starter is operated or the engine is running faster than 100 rpm. Control signals for the necessary fuel supply during acceleration are sent to the control unit from two contact strips in the throttle valve switch.

The cold start valve receives its control signals from a thermoswitch independent of the control unit.

Common Problems with the Electronic Control Unit -

Since the output of the ECU are the pulses which drive the injectors, a malfunction of the ECU can emulate a failure of any combination of failures of the detection devices feeding it. Fortunately, problems with the ECU are rare. If a fuel injection problem persists after all detection devices have been individually checked for proper operation, substitution of the control unit with one known to be good may isolate the problem to a defective ECU.

Other Common Problems -

One of the most common problems with D-Jetronic systems, and the one most frequently overlooked, is poor grounding. Defective grounds cause intermittent problems which are very difficult to troubleshoot. If you have ever had the frightening experience of flying down the freeway in the fast lane at 75 miles per hour in cool weather (minimizing the possibility of vapor lock) and suddenly losing power, you may well have a high resistance ground. These cars are now fifteen to twenty years old, and have accumulated years of dirt, grease, and corrosion. The sure cure for this problem is to gain access to the ground terminals at the top of the engine block (under the air cleaner bracket) and to thoroughly clean the push-on connectors at these terminals. A good electrical connection at the ground strap between the chassis and the transmission is also extremely important. I have seen instances where this strap appeared to be secure, but in fact the bolt securing the strap to the transmission had stripped threads, causing a very high resistance ground return. The message here is that if you're having intermittent problems, **check your grounds**.

If you're having an intermittent problem and can't seem to pin it down, you can easily determine whether the problem is the ignition or fuel injection system by using an inductively coupled timing light clamped to one of the spark plug wires from the distributor. Run the wires from the engine compartment, through the passenger side window and place the timing light on the passenger seat. When the problem occurs, pick up the light, pull the trigger, and if it flashes the ignition system is OK, and the problem is probably lack of fuel pressure in the ring main (check fuel pump, fuel pump power, and pressure regulator) or failure of the injectors to inject fuel (check detecting elements, ECU, electrical connections, grounds, etc.).

The relay board containing the main power relay, fuel pump relay, fuel pump and rear window defroster fuses, and voltage regulator among other assorted components is subject to failure after years of use. The primary failure mode is high resistance or open connections internally. The reason for this is that the circuit foil is riveted mechanically, **but not soldered**, to the connector, relay socket, or fuse holder connections. This means that the electrical connection is totally dependent on the mechanical rivet. Over time, moisture gets into the board through the surface terminals, and the mechanical joint corrodes, causing the electrical failure. This problem is corrected by using a solvent to dissolve the potting material on the bottom of the board, burnishing each of the riveted connections, then soldering them so that a good electrical connection is made. While working on the relay board, it's a good idea to replace the European fuses with an in-line fuse holder (3AG type), and solder the leads from the in-line holder to the existing exposed fuseholder terminals (see accompanying illustration).

A final source of many troublesome problems is air leaks. These can be caused by the throttle butterfly not opening or closing completely (clean residue from the butterfly and adjust throttle stops) and loose or decaying vacuum hoses (replace leaking hoses).

<u>Recommended Test Equipment and Procedures</u> -

For those who really want to be able to isolate problems without a lot of "hit or miss" guesswork, there are several pieces of test equipment which can be purchased or made at reasonable cost. These include:

- A **Breakout Box** to gain access to conductors in the wiring harness connecting the ECU to other elements in the system

- A **Volt-Ohm-Milliampmeter** with a DC sensitivity of at least 20,000 ohms/volt

- A **Fuel Pressure Gauge** capable of measuring pressures of at least 40 psi with hose and clamp to attach to test point on ring main
- An **Inductive Xenon Timing Light**

To test the various detecting elements, the breakout box is used. A schematic diagram for the breakout box is appended to this article. First, dismount the ECU from the battery tray, slide the protective cover from the harness connector end of the ECU, and remove the harness connector. Plug the harness connector onto the breakout, but **do not connect the breakout to the ECU**. This provides easy access to all the detecting elements (sensors). Test the sensors as follows:

1) To test the voltage supply to the ECU, turn on the ignition and using the V-O-M on a DC Volts range, measure the voltage between terminal 16 and terminal 11. This voltage should measure between 11 and 12.5 VDC. Repeat this measurement between terminal 24 and terminal 11. If the voltage at either of these points is below 11 VDC, there may be high contact resistance in cable 16, 11, 24, or at the relay contacts for the main power relay on the engine compartment relay board. If no voltage is present, it could mean an open circuit in the cable from the main relay to the ECU, a defective relay, or possibly a defective ignition switch.

2) Operate the starter and check the voltage between terminal 50 on the starter and chassis ground. The voltage should read between 9 and 12 VDC. If there is no voltage reading, but the starter operates, there is an open circuit from the starter to terminal 18 on the ECU.

3) To test the Pressure Sensor, with the ignition OFF, measure the resistance between terminal 11 (ground) and terminals 7, 8, 10, and 15 in turn. All readings should indicate an open circuit (infinite resistance). Zero resistance indicates a short circuit between the pressure sensor windings and ground. Confirm proper resistance of the primary windings in the pressure sensor by measuring and verifying approximately 90 ohms between terminals 7 and 15. Confirm proper resistance of the secondary windings by measuring between terminals 8 and 10. This measurement should be approximately 350 ohms.

4) To test the throttle valve switch for full load enrichment, with the ignition OFF, measure resistance between terminal 9 and terminal 11 as the accelerator is slowly depressed. The ohmmeter should alternate readings between infinity and zero ohms as the accelerator is depressed. If only zero ohms is shown, replace the throttle valve switch. With the accelerator in idle position, measure the resistance between terminals 17 and 11. This should read zero ohms. If the

resistance reading is infinity, either the switch is incorrectly adjusted or is defective. Next, measure the resistance between terminals 17 and 11 with the accelerator slightly depressed. This should read infinite ohms.

5) To test temperature sensor I (intake manifold), with the ignition OFF measure the resistance between terminals 1 and 13. With an outside air temperature of 68 degrees F, this value should be between 260 - 340 ohms. At 14 degrees F, 860 - 1200 ohms; and at 122 degrees F, between 90 - 130 ohms.

6) To test temperature sensor II (cylinder head), with the ignition OFF measure the resistance between terminals 11 and 23. At 68 degrees F, the resistance should be 2-3 k ohms; at 14 degrees F, 7-12 k ohms; and at 122 degrees F, 680 ohms - 1 k ohm.

7) To check the trigger contacts in the ignition distributor, operate the starter to turn the engine over. With the ohmmeter connected first between terminals 12 and 21, then terminals 12 and 22, the meter should alternate between zero and infinite ohms.

8) To check the injection valves, with the ignition OFF, measure resistance between terminal 11 and terminals 3, 4, 5, and 6 in turn. The resistance in each case should be approximately 2.4 ohms.

9) To check the fuel pump, pressure regulator and relay, remove the plug in the ring main test nipple and attach the pressure gauge with hose clamp. Make sure all connections are secure to prevent fuel leaks. Turn on the ignition, and on the breakout bridge terminal 19 to terminal 11 with a test lead to energize relays and operate the fuel pump. Verify pressure gauge reads 28.4 - 30.8 psi. If there is no pressure buildup in the ring main, the pump relay, fuse, interconnecting cable, or pump may be defective. If pressure is above or below the specified range, adjust the pressure regulator. If adjustment is not possible, replace the regulator.

10) To test the cold start valve and thermo-switch keep the pressure gauge connected to the ring main as in step 9.

With engine temperature above 32-50 degrees F.

Operate the starter. The pressure reading on the gauge should not drop perceptibly. If pressure falls when starter is operated, the thermo-switch is defective. Next, operate the starter with the thermo switch grounded. Pressure in the ring main should drop while the cold-start valve injects. If the pressure doesn't drop, check the resistance of the cold-start valve winding resistance at the contacts on the valve. The winding should read approximately 4.2 ohms at 68 degrees Fahrenheit.

With engine temperature below 32-50 degrees F.
Operate the starter with the thermo-switch connected normally. Pressure reading on the gauge should drop slowly. If the pressure does not drop, the thermo-switch or cold-start valve may be defective. Test the cold-start valve as described above.

Disconnect the pressure gauge and reinstall the plug in the test nipple.

11) Connect the breakout to the ECU and to the harness connector so that there is continuity between the harness connector and the ECU connector, and all conductors are available through the breakout. Switch the four LED toggle switches so that the LEDs are active. Crank the engine. If the LEDs flash, the injectors are firing, so if there is fuel pressure in the ring main and the ignition system is working (verified with the timing light), the engine should run. The only exception is if the injector pulses are too long (as in the case of an open cylinder head temperature sensor) which might flood the engine.

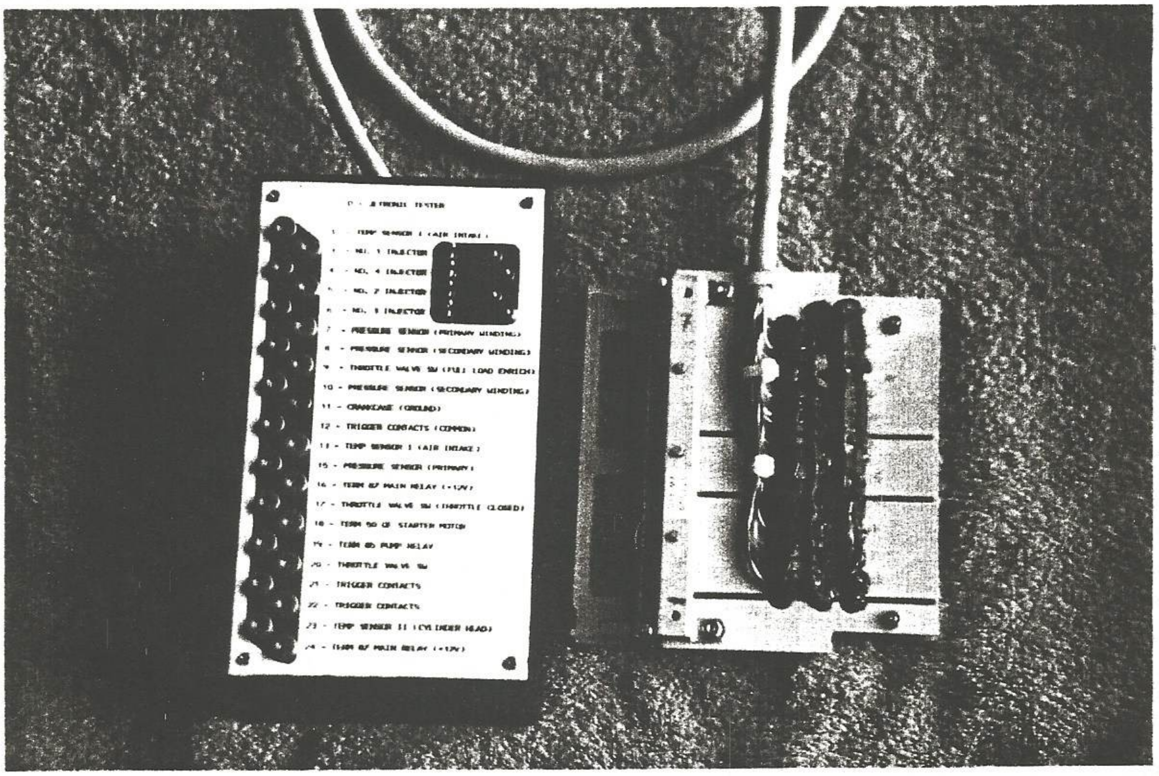
The following table provides the pinout for the wiring harness to the ECU:

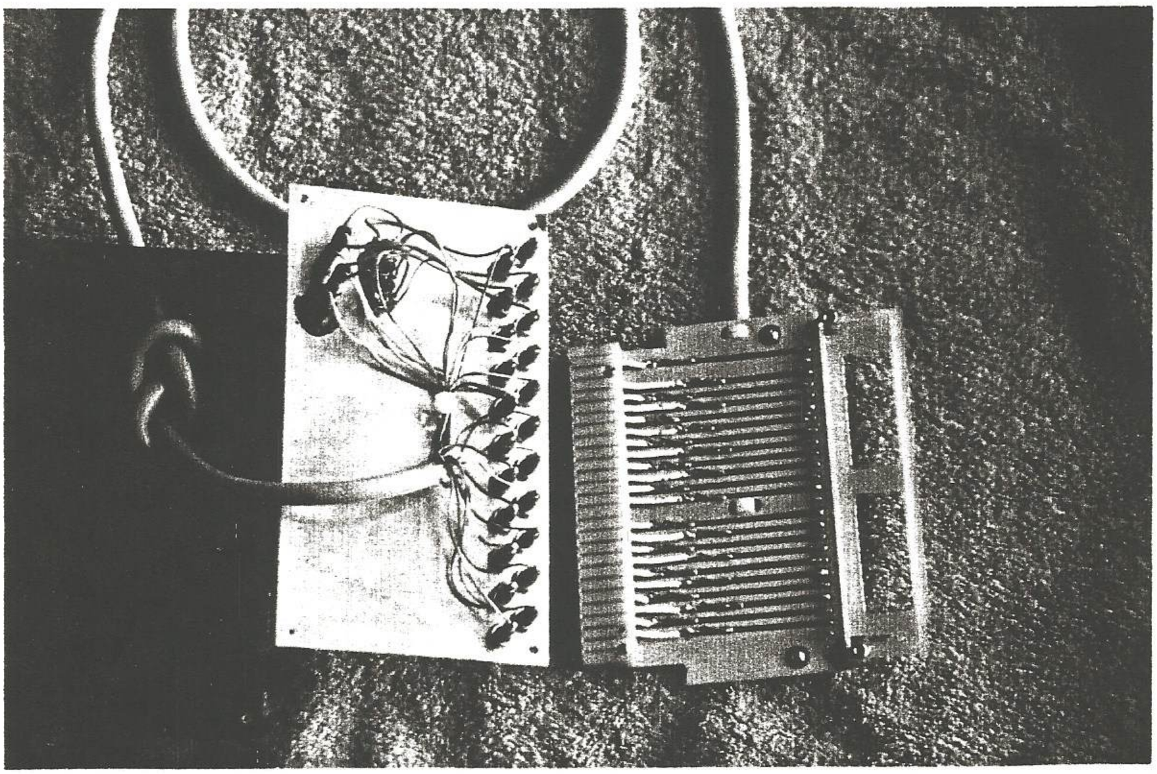
ECU CABLE HARNESS CONDUCTORS

WIRE NUMBER	FROM	TO
1.	Control Unit	Temperature Sensor I in Air Intake Distributor
2.	Not Connected	
3.	Control Unit	Number 1 Injector
4.	Control Unit	Number 4 Injector
5.	Control Unit	Number 2 Injector
6.	Control Unit	Number 3 Injector
7.	Control Unit	Pressure Sensor, Primary Winding
8.	Control Unit	Pressure Sensor, Secondary Winding
9.	Control Unit	Throttle Valve Switch, Full Load Enrichment
10.	Control Unit	Pressure Sensor, Secondary Winding
11.	Control Unit	Engine Crankcase (Ground)
12.	Control Unit	Trigger Contacts, Ignition Distributor Common
13.	Control Unit	Temperature Sensor I in Air Intake Distributor
14.	Not Connected	
15.	Control Unit	Pressure Sensor, Primary Winding
16.	Control Unit	Terminal 87 Main Relay (+12 VDC Power)
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
20.	Control Unit	Throttle Valve Switch
21.	Control Unit	Trigger Contacts, Ignition Distributor
22.	Control Unit	Trigger Contacts, Ignition Distributor
23.	Control Unit	Temperature Sensor II in Cylinder Head
24.	Control Unit	Terminal 87 Main Relay (+12 VDC Power)
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.	Terminal 50 Starter	Cold Start Valve
32.	ColdStart Valve	Temperature Switch

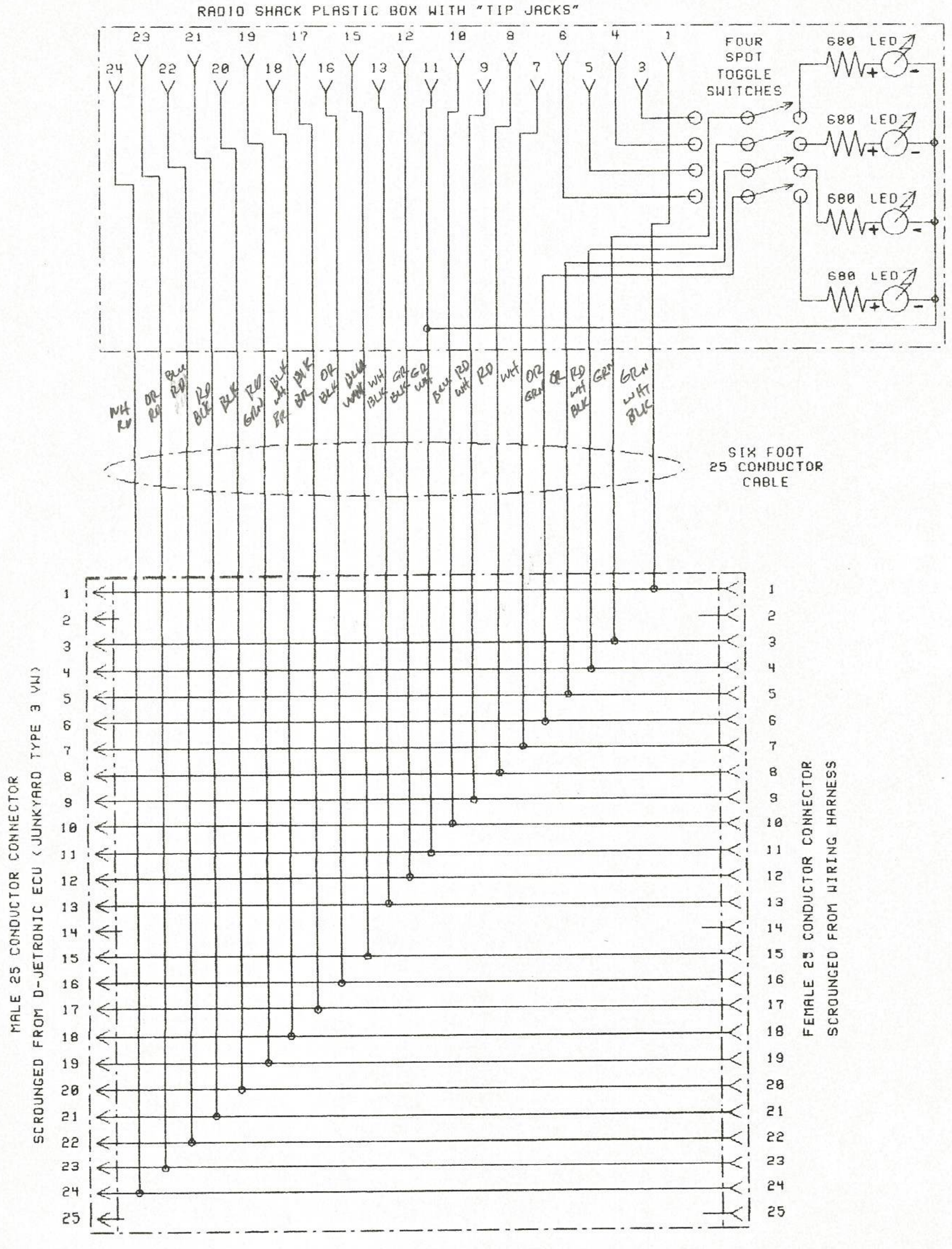
Summary -

The D-Jetronic system is basically very reliable, and once understood is easily maintained. I hope this brief article has helped a little toward a better understanding of the system. I wish to gratefully acknowledge **Partsheaven** (formerly Porsheaven) of El Cerrito, CA, for providing demonstration parts, advice and much encouragement.


7 - PRESSURE SENSOR (PRIMARY WINDING)
8 - PRESSURE SENSOR (SECONDARY WINDING)
9 - THROTTLE VALVE SW (FULL LOAD ENRICH)
10 - PRESSURE SENSOR (SECONDARY WINDING)
11 - CRANKCASE (GROUND)
12 - TRIGGER CONTACTS (COMMON)
15 - PRESSURE SENSOR (PRIMARY)
16 - TERM 87 MAIN RELAY (+12V)
17 - THROTTLE VALVE SW (THROTTLE CLOSED)
18 - TERM 50 OF STARTER MOTOR
19 - TERM 85 PUMP RELAY
20 - THROTTLE VALVE SW
21 - TRIGGER CONTACTS
22 - TRIGGER CONTACTS
23 - TEMP SENSOR II (CYLINDER HEAD)
24 - TERM 87 MAIN RELAY (+12V)



BOSCH D-JETRONIC FUEL INJECTION
TEST BREAKOUT BOX



CONNECTORS AND WIRING MOUNTED ON PERFBOARD

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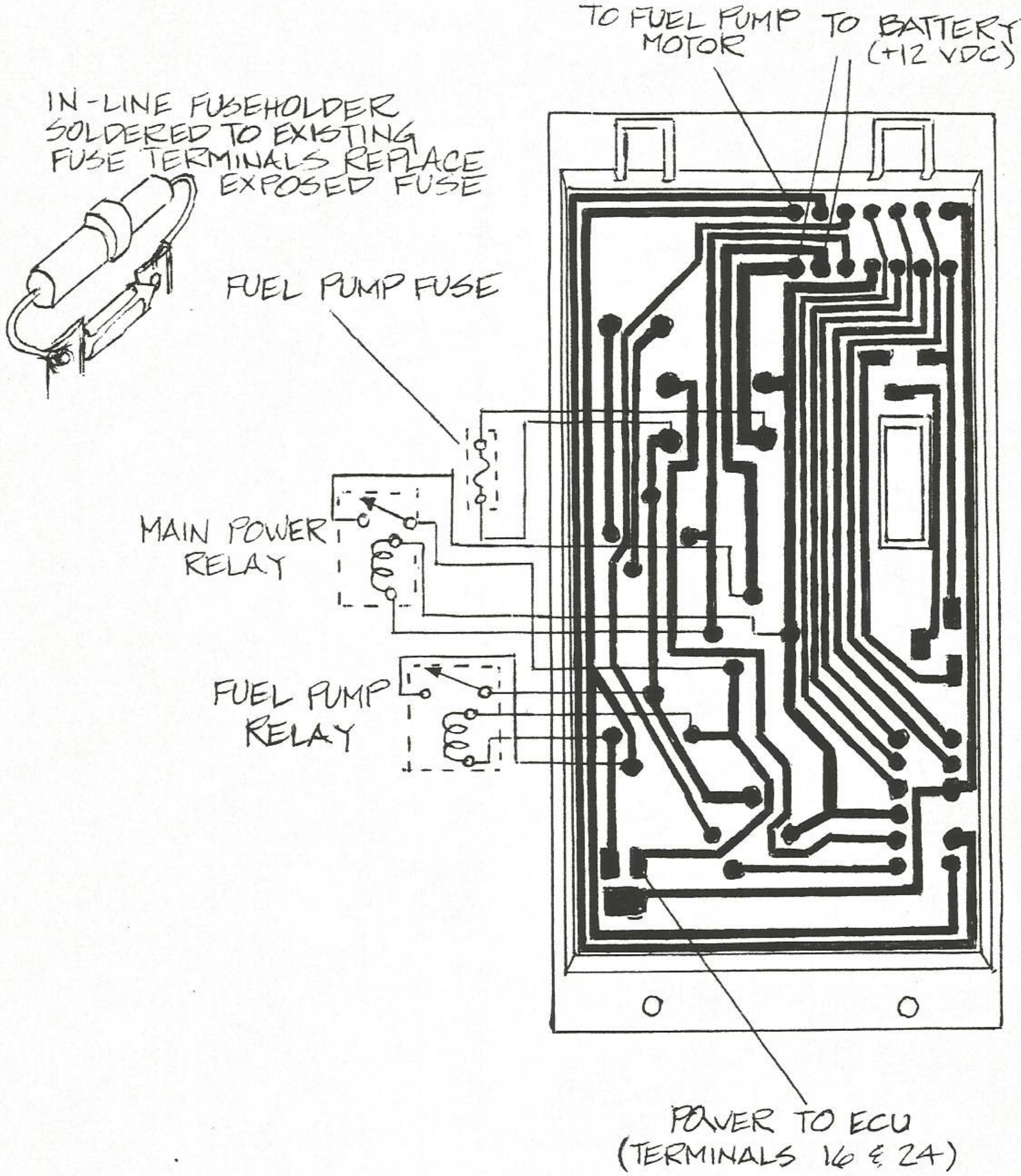
RELAY BOARD



NOTES ON IMPROVING RELIABILITY OF FUEL PUMP POWER

1) REMOVE RELAY BOARD, BATHE IN SOLVENT OVERNIGHT TO FACILITATE REMOVAL OF MOISTURE BARRIER POTTING COMPOUND.
2) AFTER REMOVING POTTING MATERIAL TO EXPOSE FOIL CONDUCTORS, SOLDER ALL RIVETED TERMINALS TO ACHIEVE GOOD ELECTRICAL CONNECTION.
3. USE "RUBBER-IN-A-TUBE" ELECTRICAL INSULATION COMPOUND (NON-CORROSIVE) TO RESTORE MOISTURE BARRIER.
4. REMOVE EUROPEAN TYPE FUSE, SOLDER IN-LINE TYPE FUSEHOLDER TO FUSE TERMINALS AS SHOWN IN SKETCH.

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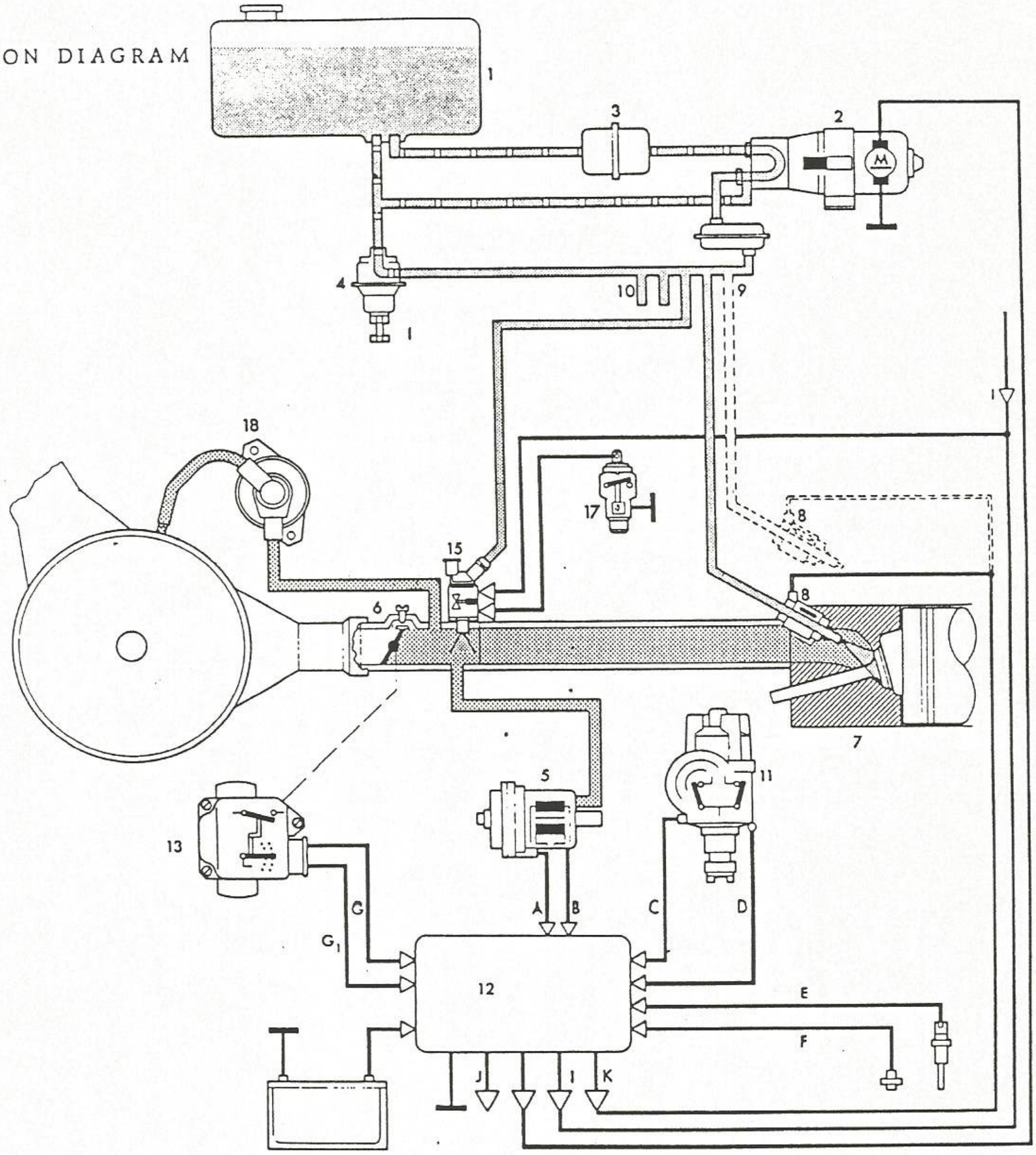
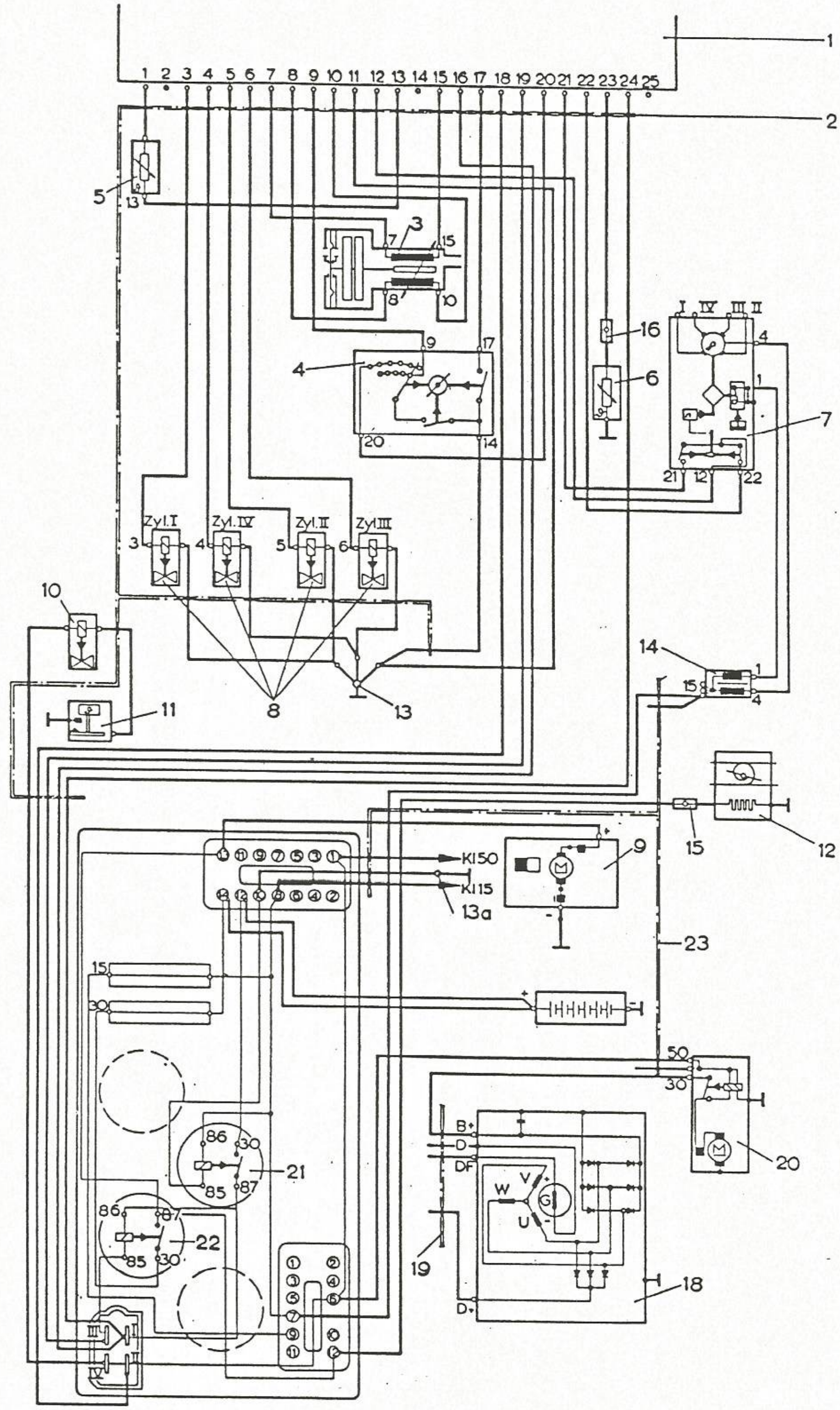
FUNCTION DIAGRAM



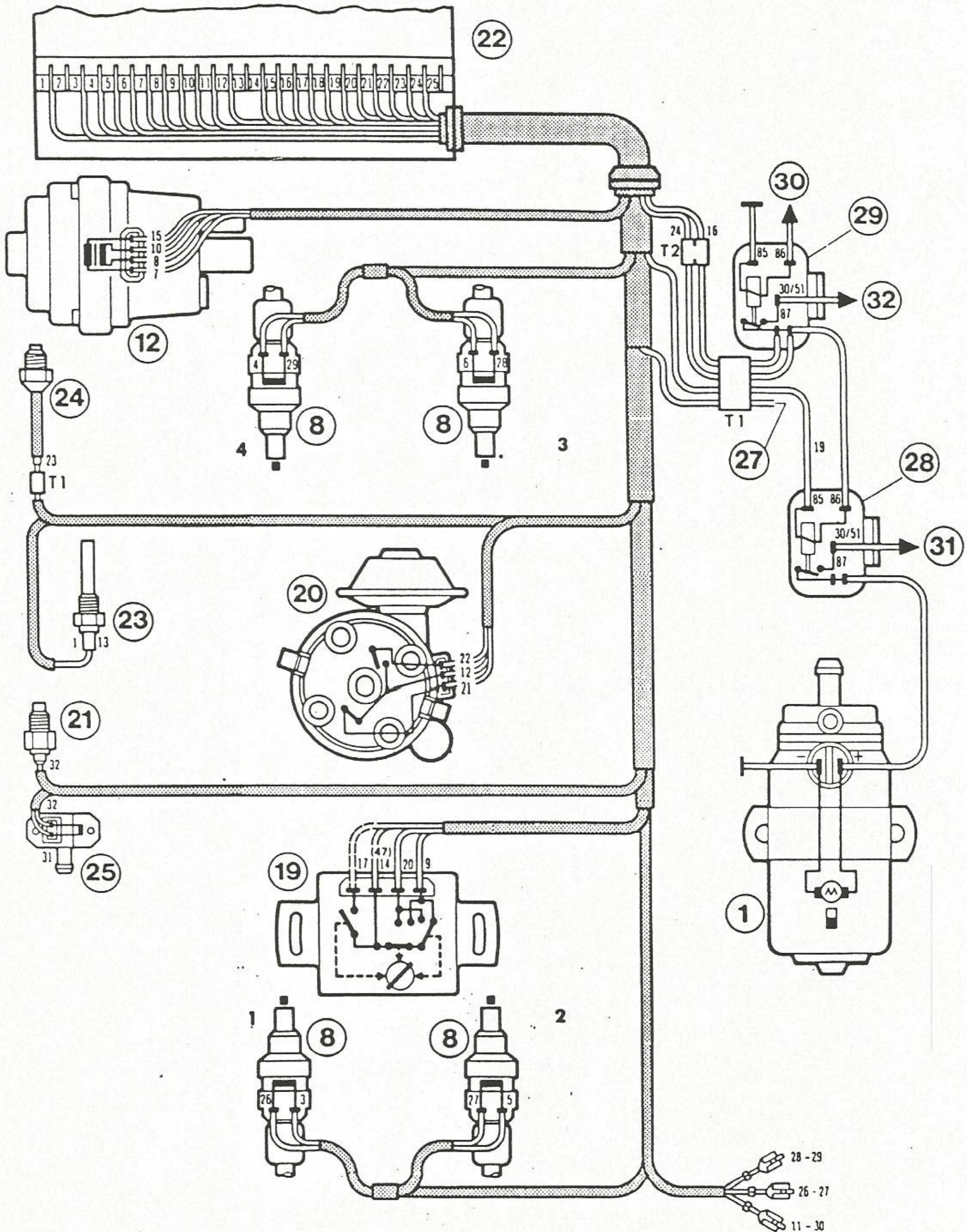
1 - Fuel tank
2 - Fuel pump
3 - Fuel filter
4 - Pressure regulator
5 - Pressure sensor
6 - Intake air distributor
7 - Cylinder head
8 - Injectors
9 - Fuel distributor
10 - Fuel distributor
11 - Ignition distributor with trigger contacts I and II
12 - Control unit
13 - Throttle valve switch with acceleration enrichment
15 - Cold starting valve
17 - Thermoswitch for cold starting valve
18 - Auxiliary air regulator
19 - Deceleration mixture control valve

A + B - from pressure sensor (load condition signal)
C + D - from ignition distributor contacts (engine speed and release signals)
E + F - from temperature sensors (warm-up signals)
G - from throttle valve switch
G 1 - acceleration enrichment
I - to injectors for cylinders 1 and 4
II - to injectors for cylinders 2 and 3



Legend:

1 - Control unit
2 - Control unit harness
3 - Pressure sensor
4 - Throttle valve switch with acceleration enrichment
5 - Temperature sensor I (intake air distributor)
6 - Temperature sensor II (cylinder head)
7 - Ignition distributor with trigger contacts
8 - Injectors
9 - Fuel pump
10 - Cold starting valve
11 - Thermoswitch for cold starting valve
12 - Auxiliary air regulator
13 - Ground connection (at engine housing)
14 - Ignition coil
15 -
16 - Connectors
17 - Regulator for alternator
18 - Alternator
19 - Alternator harness
20 - Starter
21 - Voltage supply relay
22 - Pump relay
23 - Wires contained in main electrical harness



① Electric fuel pump
⑧ Solenoid-operated injection valve
⑫ Pressure sensor
⑲ Throttle valve switch with momentary enrichment
⑳ Ignition distributor with trigger contacts
㉑ Thermo (-time) switch
㉒ Electronic control unit/ECU
㉓ Temperature sensor I in intake manifold
㉔ Temperature sensor II in cylinder head
㉕ Cold-start valve
㉗ Cables 18 and 31 from starting motor terminal 50
㉘ Pump relay
㉙ Main relay
㉚ To ignition switch terminal 15 (fuse box)
㉛ To fuse box terminal 30
㉜ To battery
T_1 Printed-circuit board plug connection
T_2 Cable connector

Trouble-shooting guide for D-Jetronic fuel injection

This guide is designed to be used in conjunction with the Robert Bosch Jetronic Service Manual.

SYMPTOM

Engine cranks but does not start	Engine starts but then dies	Rough or unstable idle	Idle speed incorrect	Erratic running	Engine misses when driving	Fuel consumption too high	No maximum power	CAUSE	REMEDY
●	●	●	●	●	●	●	●	Defect in ignition system	Check battery, distributor, plugs, coil and timing
●	●	●	●	●	●	●	●	Mechanical defect in engine	Check compression, valve adj. and oil pressure
●								Fuel pump not operating	Check pump fuse, pump relay and pump
●	●							Relay defective; wire to injector open	Test relay, check wiring harness
●	●	●					●	Blockage in fuel system	Check fuel tank, filter and lines for free flow
	●	●	●	●	●		●	Leaks in air intake system	Check all hoses and connections; eliminate leaks
		●		●	●	●	●	Fuel system pressure incorrect	Test and adjust at pressure regulator
	●				●			Trigger contacts in distributor defective	Replace trigger contacts
●		●				●		Cold start valve defect	Check for spray or leakage
●								Thermo-time switch defective	Test thermo-time switch for correct function
	●		●					Auxiliary air valve not operating correctly	Must be open with cold engine; closed with warm
●	●					●		Temperature sensor II defective	Test for 2-3 k Ω at 68° F.
●	●	●		●		●	●	Pressure sensor defective	Test with ohmmeter
		●	●				●	Throttle butterfly does not completely close or open	Readjust throttle stops
		●	●	●			●	Throttle valve switch incorrectly adjusted or defective	Adjust as necessary or replace
	●	●	●					Idle speed incorrectly adjusted	Adjust idle speed with bypass screw
		●	●	●	●		●	Defective injection valve	Check valves individually for spray
●	●	●		●	●			Loose connection in wiring harness or system ground	Check and clean all connections
●	●			●	●		●	Control unit defective	Use known good unit to confirm defect