Ferrari

Service Bulletin

SB 10-13
2/5/85

SUBJECT: Model Year 1984/85 Bosch K-Jetronic with Lambda Control
VEHICLES: All 8 Cylinder Vehicles

SERVICE INFORMATION:

Changes ~~to~~ from M.Y. 1983

1) Single three way catalyst with exhaust manifolds of front and rear bank joined together.

2) Oxygen sensor (λ sond) at TWC inlet, and related control circuit for fuel delivery.

3) "Pulse injection system" for secondary air, instead of air pump assembly.

4) Warm up regulator no longer controlled by manifold vacuum; only works during warm-up period and adjusts control pressure for altitude compensation.

   a) Enrichment at full throttle achieved by throttle microswitch, affecting "duty cycle" of metering valve.

   b) Enrichment during acceleration, with cold engine only, by additional spray of cold start injector controlled by a differential pressure valve. Thermo-time switch closed (below 45°C). 113°F

5) Auxiliary air for cold starting throttle through a single, bigger diameter, auxiliary air valve.

PRINCIPLES OF OPERATION

1) K-Jetronic Metering Unit with Oxygen Sensor Control Systems:

The basic principle of constant pressure difference across the metering slots becomes slightly altered, thus the fuel flow can vary with the position of control plunger remaining constant (= constant metering slot opening), according to variations of pressure difference is governed by the oxygen sensor control system in order to keep the air/fuel ratio within a very narrow band across stoichiometric (or λ value) for better efficiency of the TWC.

a) Control function (see figure 1):

Fuel pressure levels in metering unit:

Ps = Primary pressure, constant and controlled by pressure relief valve;

P1 = Pressure in lower chambers of differential pressure valves;

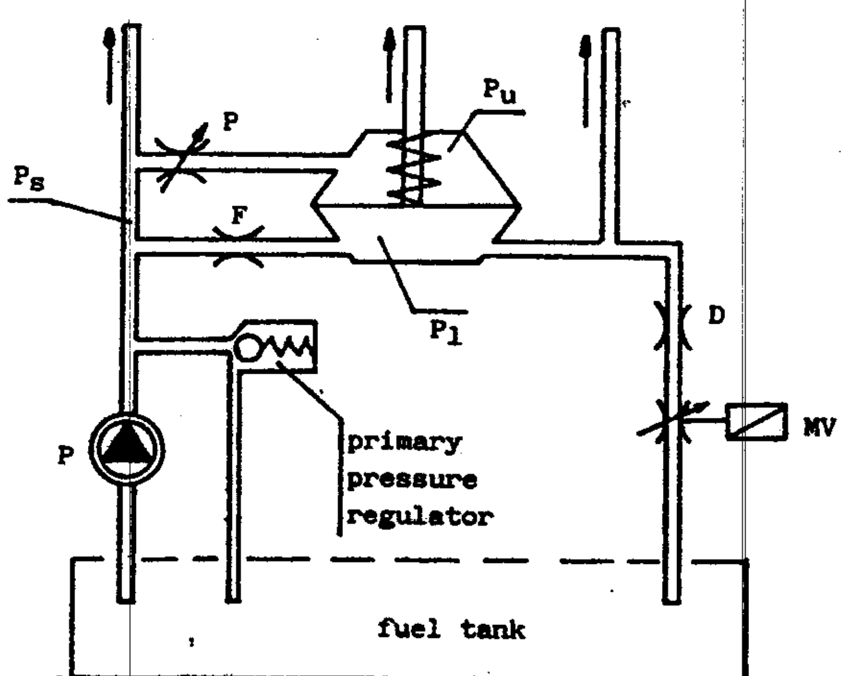
Max = Ps (drain closed)
Min = Ps moves 0.18 bar (drain fully open)
2.6 PSI

Pc = Control pressure, determined by warm up regulator, affecting the vertical displacement of the control plunger, and the opening of the metering slots. For simplicity, in this description, the metering slot opening is considered constant, thus the effect of the control pressure is not taken into account;

DP = Pressure difference across metering slot = Ps - Pu. Of course the fuel delivery to each fuel injector is proportional to "DP"; DP = Ps - Pu = Ps - (Pc - 0.14 bar) = Ps - Pc + 0.14.

P1-Pu=Δ P, remains always constant due to the effect of the differential pressure valves (Δ P = 0.14 bar approximately).

Identical for Each Cylinder



All 8 lower chambers of differential pressure valves are interconnected by a channel, at the end of which there is an additional drain through which fuel can escape back to the fuel tank.

This drain is controlled by a variable opening solenoid type valve called "metering valve."

Thus, when the metering valve is closed, the pressure in the lower chambers (P1) becomes equal to the primary pressure (Ps); when the metering valve is open P1 stabilizes to a pressure valve lower than Ps: with metering valve fully open P1 becomes equal to (Ps - 0.18 bar) approximately. Due to the presence of the differential pressure valves, a decrease of P1 will determine an identical decrease of Pu (fuel pressure in the upper chambers) in order to always keep P1-Pu = constant = 0.14 bar. Finally, the pressure difference across the metering slots can vary within the following range:

1 - Metering valve fully open: P1 = Ps, and Pu = Ps - 0.14 = Ps - 0.14 bar

<u>DP = 0.14 bar</u>

2 - Metering valve fully open: P1 = Ps - 0.18 bar, Pu = P1 - 0.14 bar = Ps - 0.32 bar

<u>DP = 0.32</u>

This final result shows how the pressure difference across the metering slots can change and determine proportionally a fuel delivery change, without any movement of the control plunger, but only as a consequence of the metering valve opening.

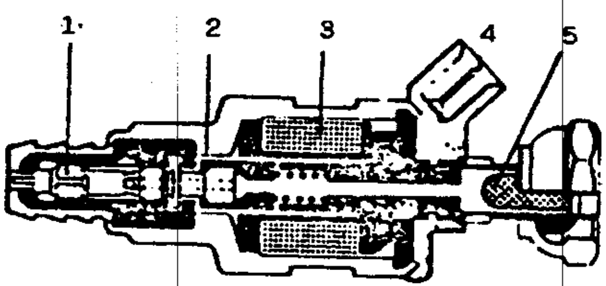
b) Metering Valve:

Is a solenoid type valve, open when energized, controlled by the Injection Electronic Control Unit (ECU). The ECU supplies to the metering valve an intermittent voltage (see figure 2) at the constant frequency of 70 Hz, each pulse being a "square wave" with a "duty cycle" (or ON/OFF ratio; On being 12 Volts Off being 0 Volts) which changes according to the engine operating conditions in order to determine longer or shorter opening periods of the metering valve.

In practice, the duty cycle specifications are:

Minimum: Less than 20%;
Maximum: More than 87%.

In order to dampen the fuel pressure peaks generated by the pulsating type of operation of the metering valve, there is a capacity installed on the drain pipe between fuel metering unit and metering valve.



1 - Needle
2 - Solenoid Aramature
3 - Solenoid Coil
4 - Electrical Connection
5 - Fitter

Figure 2

2) Main Electronic Control Circuit, with Oxygen Sensor System:

Governs the metering valve in order to slightly modify the basic air/fuel ratio established by the calibration of the fuel metering unit and air flow sensor in the Bosch K-Jetronic assembly. Is made up by:

a) Oxygen sensor: (see Figure 3) is a cell which can be considered as a non-liquid electrolyte, made mainly of zirconium dioxide, with surfaces by a gas permeable layer of platinum, exposed to the exhaust gases at the catalyst inlet. The exterior surface is protected by a ceramic layer.

Once warmed up (temperature above 300°C or 570°F) it generates a voltage signal ranging from 0.1 Volts to 1.0 Volts (see Figure 4. according to whether there is presence or not of unburnt oxygen in the exhaust gases, or whether the air/fuel ratio is lean (presence of unburnt oxygen) or rich (no oxygen in the exhaust).

This signal is sent to the ECU which, in turn, will control the metering valve in order to increase the fuel delivery if the signal from the oxygen sensor corresponds to lean mixture, or decrease the fuel delivery once the fuel mixture becomes too rich and the oxygen sensor releases the corresponding signal.

The final result is a "closed Loop Control Circuit" where the fuel delivery becomes adjusted and re-adjusted continuously in order to keep the air/fuel ratio within a narrow band from stoichiometric.

At temperatures lower than 300°C (570°F), the internal resistance of the oxygen sensor prohibits obtaining a distinct signal.

In order to reduce the "lighting up" time at cold startings and keep good efficiency if the engine is left idling for long periods, the oxygen sensor, in addition to the exhaust gases, it heated by a resistance that winds the ceramic body.

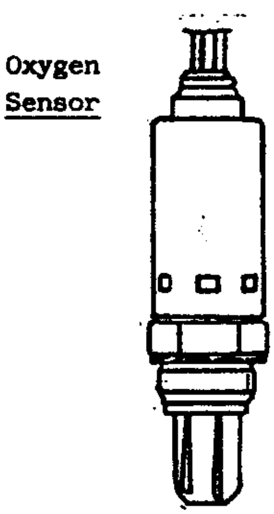


Figure 3

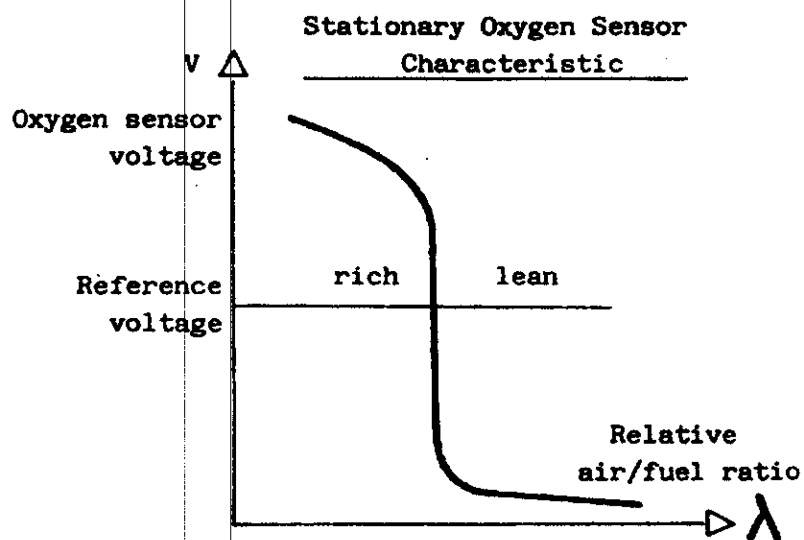


Figure 4

b) Injection Electronics Control Unit (ECU): is the brain of the system and energizes the metering valve, controlling itsoperating conditions, according to the different inputs received basically from the oxygen sensor, but also from engine oil and engine coolant thermoswitches, catalyst temperature control unit, throttle microswitch (see block diagram).

According to the input signals, the ECU can release an output (voltage to the metering valve) such to establish either:

Closed Loop Control Circuit = continuous periodical adjustments and re-adjustments, or;

Open Loop Control Circuit = Steady type of operation.

CLOSED LOOP CONTROL CIRCUIT - OPERATING PRINCIPLES (see Figure 5-8)

The fuel injection system is controlled (or better, adjusted) by the oxygen sensor in order to deliver an air/fuel ratio within a narrow range across stiochiometric.

As can be seen from Figure 4, the oxygen sensor signal distinctly changes as the oomposition of the exhaust gases passes from rich to lean (or the opposite); in the ECU, the sensor output is compared with a predetermined threshold by comparator no. I, which will identify whether the exhaust is momentarily rich or lean, and will determine in which direction the integrator has to work. The integrator output is a continuous voltage which increases if mixture is lean, and needs to be enriched, or decreases if mixture is rich and needs to be leaned.

The integrator output is fed to Comparator no. II, where it is weighted against a sawtooth pulsating voltage of 70 Hz coming from the sawtooth generator. The minimum and maximum values of the sawtooth pulses are constant and autsied (below and above respectively) the range of the integrator output voltage.

The output of comparator no. 2 becomes a "square wave" pulsating voltage of 70 Hz with ON/OFF periods, or duty cycle, determined by the intersection points between the integrator voltage and the increasing/decreasing ramp of the sawtooth pulses. This output, after being amplified, will constitute the control signal energizing the metering valve, in the following manner: higher integrator voltage corresponds to lean signal of oxygen sensor, and generates higher duty cycle of metering valve, which means more valve opening and higher pressure difference across the metering slots, thus establishing richer mixture; and viceversa.

NOTE: The oxygen sensor is placed on the exhaust side, while the corrections to the air/fuel ratio take place on the intake side, and this means there is a delay time in the control logic of the system. In fact, the integrator output will continue to move in a specific direction (increasing or decreasing) until comparator no. 1 identifies that the oxygen sensor output has changed and has passed across $\lambda = 1$, even though the integrator output has already passed across $\lambda = 1$. This "wrong direction" of the integrator continues for a period equal to the delay time of the system, which has been optimized with respect to driveability and emissions. Figure 8 shows the "action circle" of the closed loop control mode, with oxygen sensor feedback.

ECU - Block Diagram

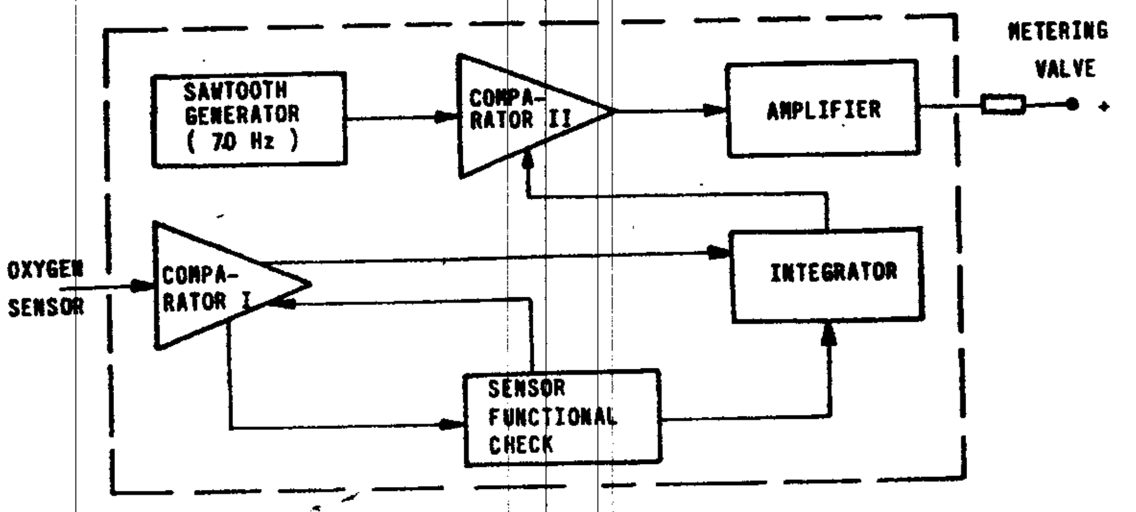


Figure 5

Metering Valve Frequency

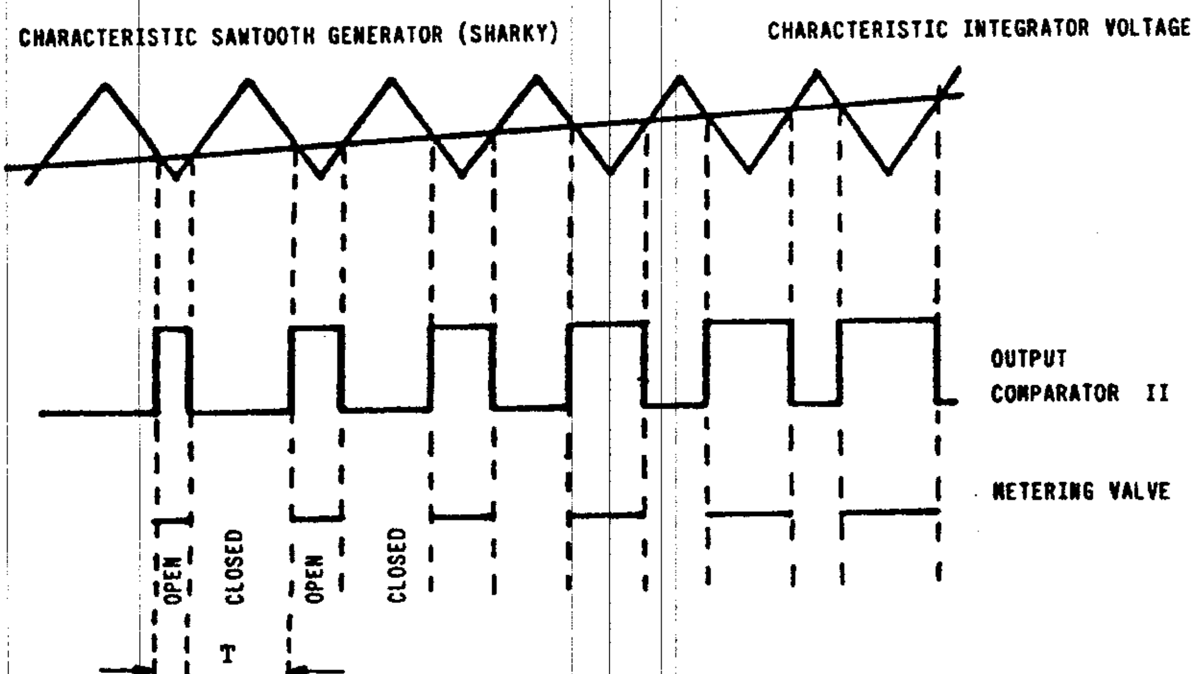


Figure 6

ECU - Block Diagram

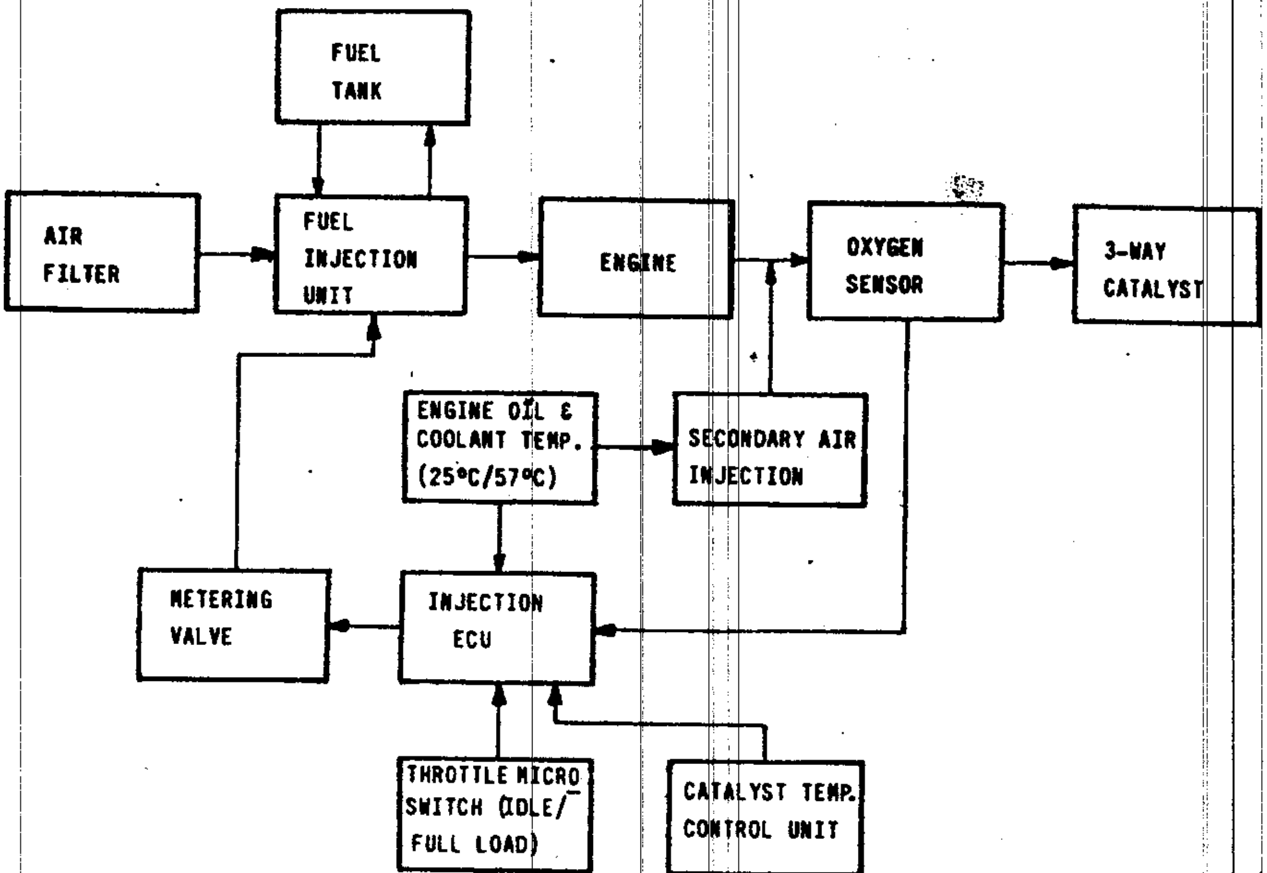


Figure 7

Closed Loop Mode (with Oxygen Sensor Feedback)

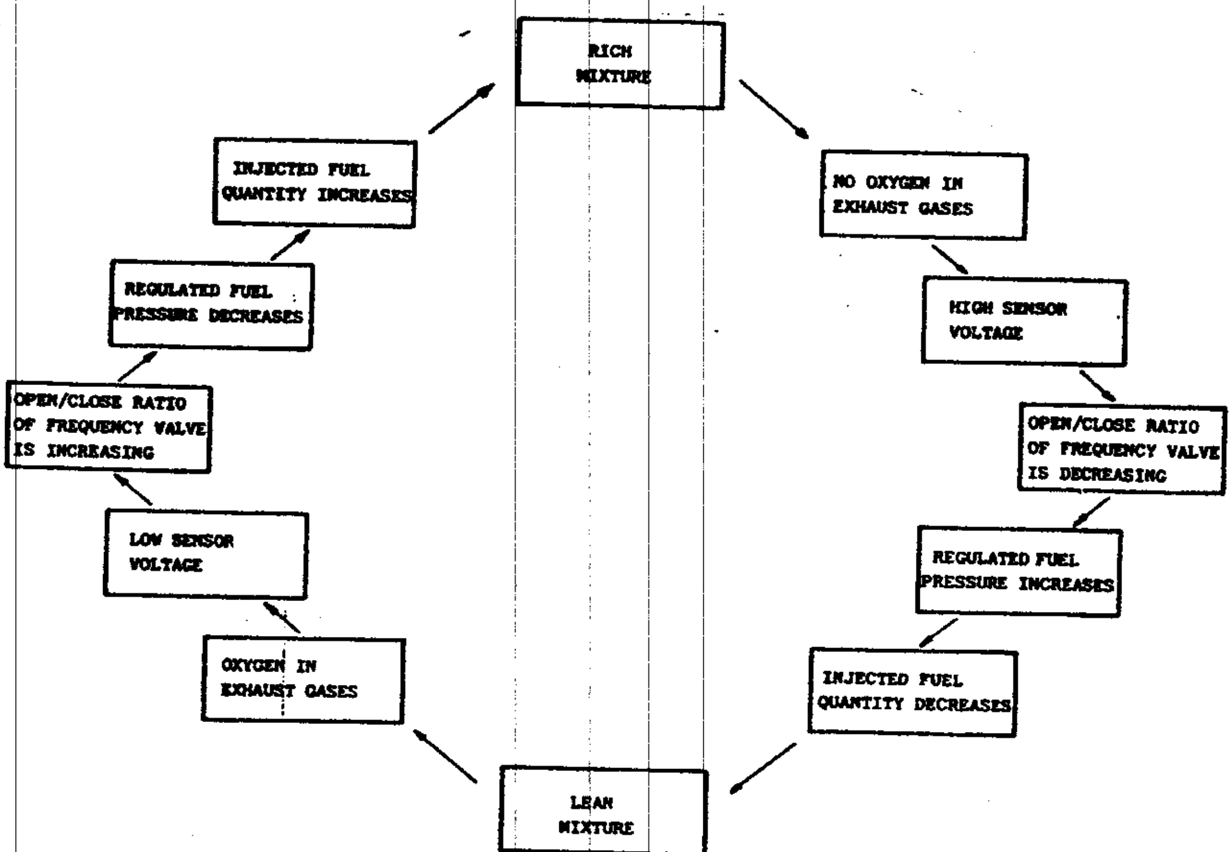


Figure 8

<u>OPEN LOOP CONTROL CIRCUIT - OPERATING PRINCIPLES</u>

The metering valve operates with a steady duty cycle independent from oxygen sensor signal.

This will happen in the following conditions:

<u>Oxygen Sensor Cold</u> - with temperature below 300°C (or 570°F): the "sensor functional check" unit, incorporated in the ECU (see Figure 5) will identify height internal resistance of oxygen sensor (approximately higher than 1 Mega-Ω), and will control the integrator in order to achieve a steady duty cycle of the metering valve. The same will happen if the connection between oxygen sensor and ECU is interrupted (infinite resistance). This fixed duty cycle, <u>with oxygen sensor cold or interrupted</u>, can have the following values:

o 65% open/35% closed, with engine oil temperature below 76F 25 ± 3°C.

o 50% open/50% closed, with engine oil temperature above 25 ± 3°C.

o With engine oil temperature above 25°C, independently from oxygen sensor temperature (or resistance), the duty cycle remains 50% until the engine coolant temperature exceeds 57 ± 3°C. 134°F

For this purpose there are two thermoswitches:

o Engine oil temperature switch (open above 25 ± 3°C (77°F), closes below 15 ± 3°C (59°F)), located near oil sump on metal connector for drain pipe from blow-by separator.

o Engine coolant temperature switch (open above 57 ± 3°C (134°F), closes below 33 ± 3°C (91°F)) located on coolant expansion tank.

NOTE: Cold engine oil (below 25°C) has priority on cold engine coolant (below 57°C), which in turn has priority on oxygen sensor temperature, in order to establish the "open loop" constant duty cycle (see diagram on Figure 10).

Full throttle operation, detected by a throttle microswitch, which will provide a ground connection, joining, in parallel, the outlet of engine oil thermoswitch, at wide open throttle, thus generating a 65% duty cycle (rich mixture). Also see wiring diagram Figure 9.

In this condition, the ECU feels the same input as with cold engine oil.

Open loop control can be artificially generated for check purposes also in the following conditions, with engine warm:

o ECU inlet disconnected from oxygen sensor and connected to ground (0 volts): the duty cycle will become stabilized and constant to its maximum value of rich mixture (above 87% max).

o ECU inlet disconnected from oxygen sensor, and connected to a 1.5 - 2 Volts DC supply: the duty cycle will become stabilized and constant to its minimum value of lean mixture (below 20% max).

o ECU inlet from sensor disconnected or interrupted: same condition as oxygen sensor cold (duty cycle 50% with engine warm).

CLOSED LOOP MODIFIED SETTING

For narrower fluctuations of air/fuel ratio and more stable engine running the amplitude of the integrator output (integrator voltage) is reduced in the following conditions:

o At idle (condition recognized by the throttle microswitch).

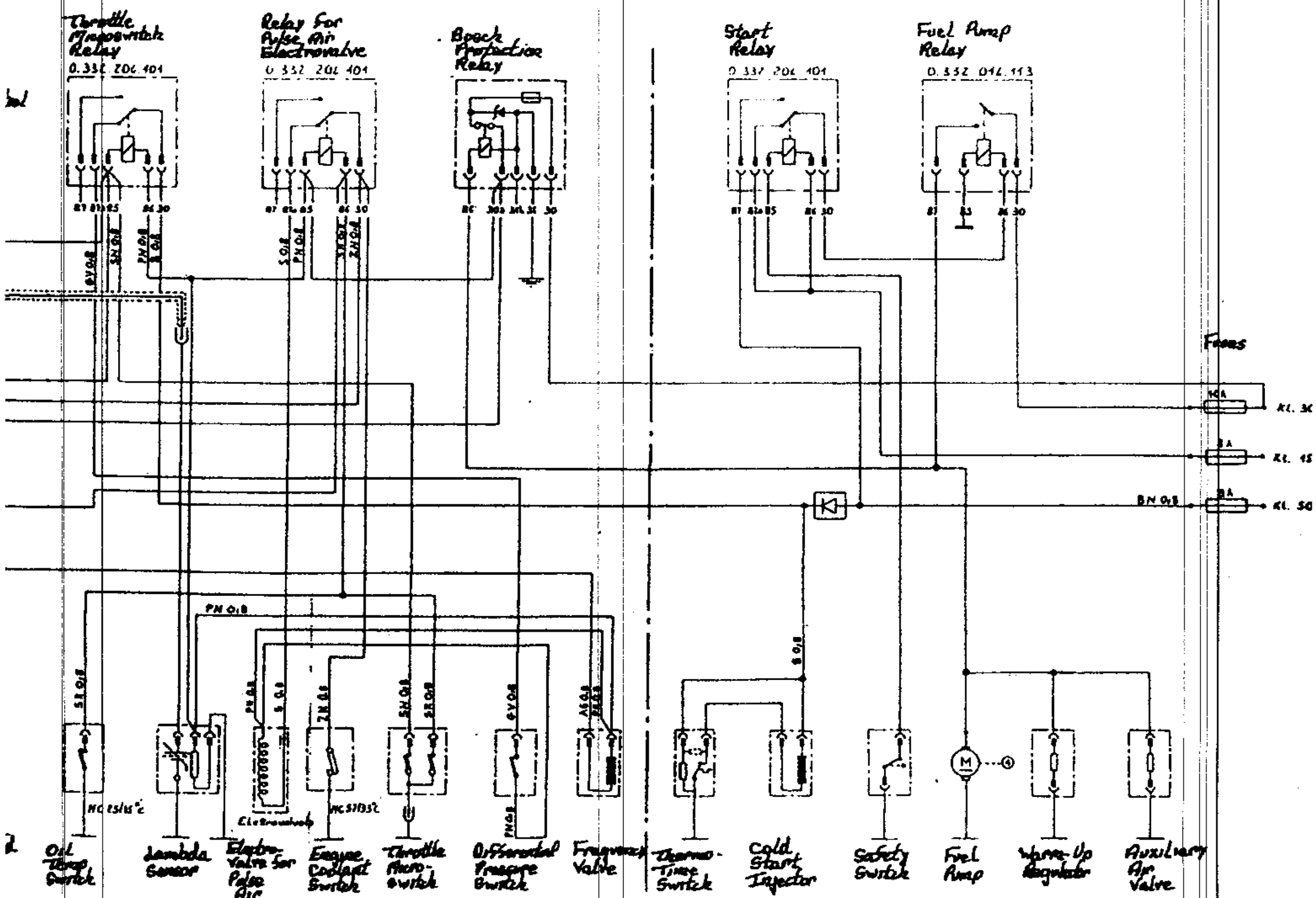
1256°F

o Engine warm, with catalyst temperature higher than 680 $\pm$ 20°C (1256 $\pm$ 36°C). This condition is recognized via a thermocouple, by the catalyst temperature control unit.

BUILT IN FUNCTIONAL CHECKS

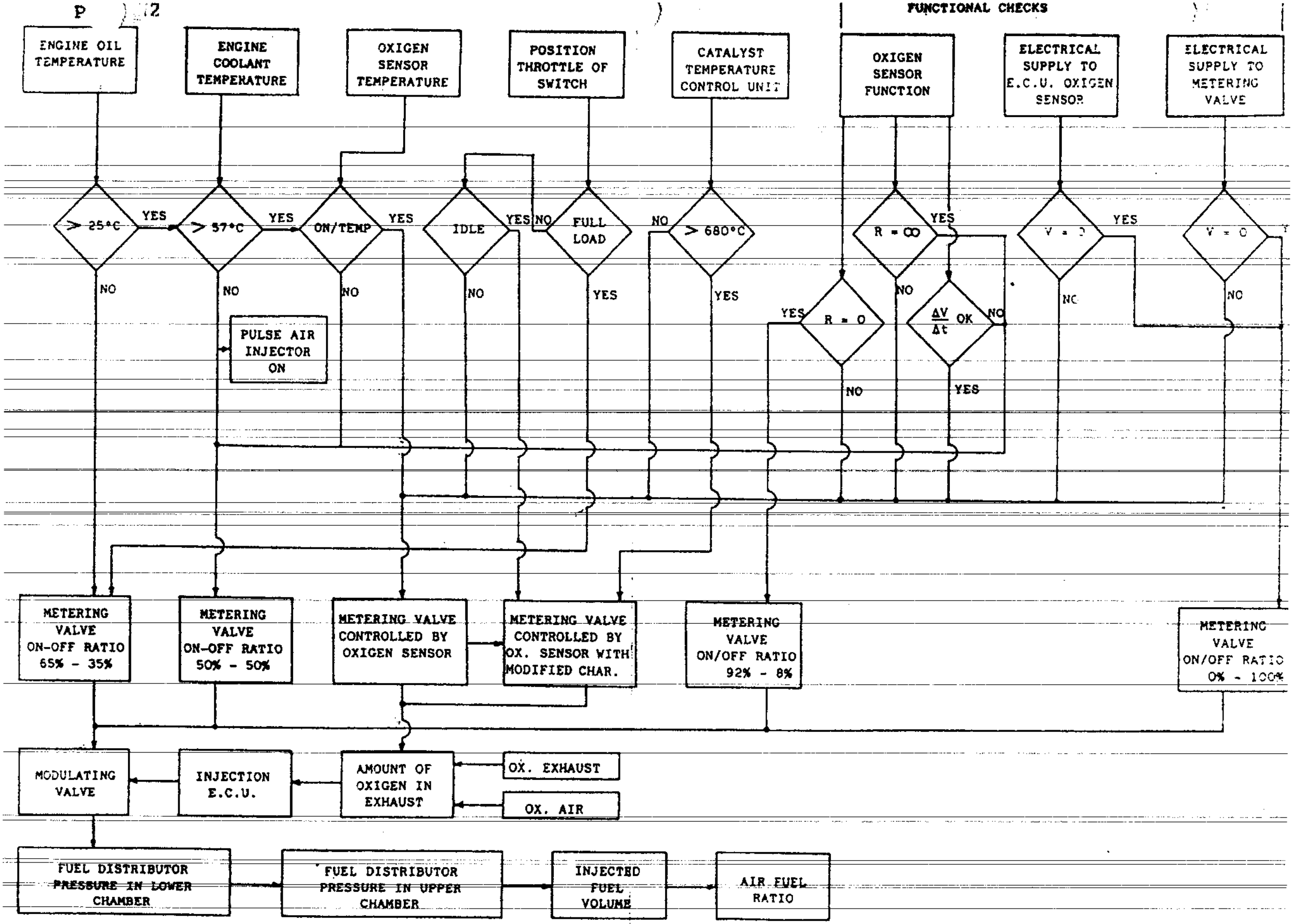
The ECU determines about every 10 seconds of operation that the system is working. If comparator no. I (on Figure 5) has not shifted (indicating passage through $\lambda = 1$) in this time span either the sensor or the ECU (or possibly some part in the basic fuel injection system) is not properly functioning. This will cause the ECU to shift the pulse valve into the open control circuit mode of operation (50%). In this case the engine will also operate in the $\lambda = 1$ range.

Wiring Diagram



ECU Connector (25 pins)

Figure 9



FUNCTIONAL CHECKS
ENGINE OIL TEMPERATURE
ENGINE COOLANT TEMPERATURE
OXIGEN SENSOR TEMPERATURE
POSITION THROTTLE OF SWITCH
CATALYST TEMPERATURE CONTROL UNIT
OXIGEN SENSOR FUNCTION
ELECTRICAL SUPPLY TO E.C.U. OXIGEN SENSOR
ELECTRICAL SUPPLY TO METERING VALVE
> 25°C
> 57°C
ON/TEMP
IDLE
FULL LOAD
> 680°C
R = ∞
R = 0
ΔV/Δt OK
V = 0
YES
NO
PULSE AIR INJECTOR ON
METERING VALVE ON-OFF RATIO 65% - 35%
METERING VALVE ON-OFF RATIO 50% - 50%
METERING VALVE CONTROLLED BY OXIGEN SENSOR
METERING VALVE CONTROLLED BY OX. SENSOR WITH MODIFIED CHAR.
METERING VALVE ON/OFF RATIO 92% - 8%
METERING VALVE ON/OFF RATIO 0% - 100%
MODULATING VALVE
INJECTION E.C.U.
AMOUNT OF OXIGEN IN EXHAUST
OX. EXHAUST
OX. AIR
FUEL DISTRIBUTOR PRESSURE IN LOWER CHAMBER
FUEL DISTRIBUTOR PRESSURE IN UPPER CHAMBER
INJECTED FUEL VOLUME
AIR FUEL RATIO

Figure 10

Additional Fuel During Acceleration with Cold Engine (Figure 11)

With the engine block still cold (temperature below 45°C), the cold start injector gives additional fuel under the control of the thermo-time switch (providing ground) and the differential pressure switch (providing a positive). The latter, via a vacuum hose, is connected to the intake manifold, and closes momentarily when vacuum decreases quickly.

In fact, the closing of the electrical contact is achieved by a diaphragm, held by a spring, and having a calibrated small hole. A sudden decrease of vacuum will displace the diaphragm against the electrical contacts for a certain period, until the modified vacuum condition becomes equal on both sides of the diaphragm.

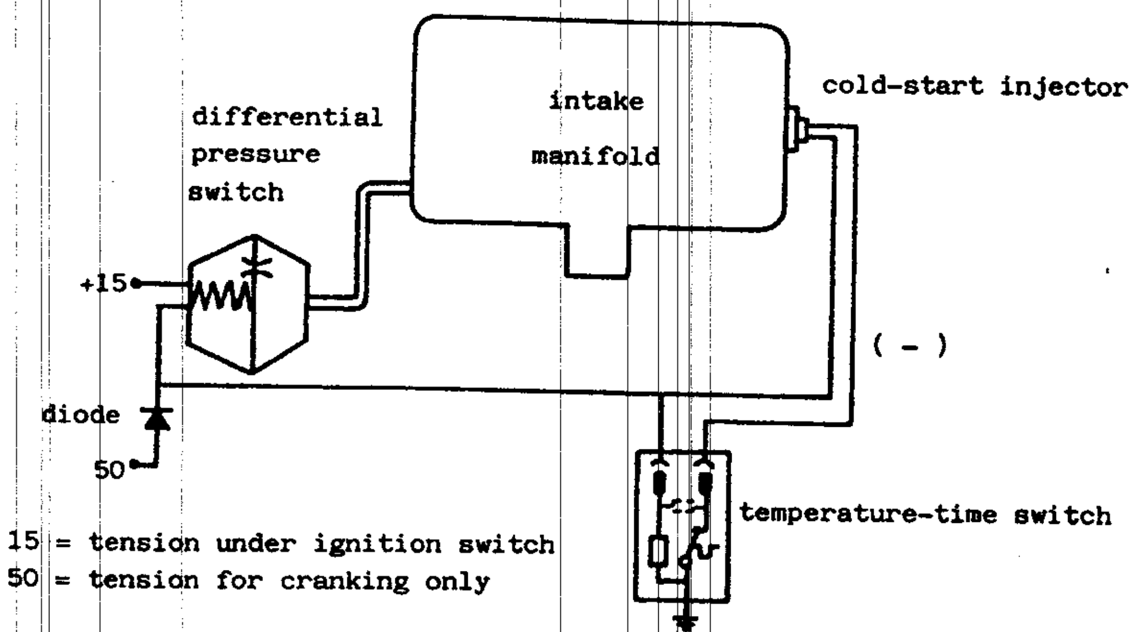


Figure 11

PULSE AIR INJECTION SYSTEM (Figure 1?)

It provides secondary air to the engine exhaust parts, during engine warm up period, with engine oil temperature above 25°C and engine coolant temperature below 57°C (while the oxygen sensor control system is operating at a constant 50% duty cycle), in order to reduce the catalyst "lighting-up" time. In order to amplify said effect, the exhaust manifolds are properly insulated.

NOTE: Any secondary air at the exhaust, while the oxygen sensor system is operating in the normal conditions of "closed loop control circuit" would greatly upset the control function, and must be avoided.

For the reasons discussed above, if leaks in the exhaust system should become present, they must be repaired and eliminated as the control function would be upset.

The secondary air injection is cut off at engine oil temperature below 25°C to protect the catalyst from overheating due to the enriched air/fuel mixture (65% duty cycle of metering valve).

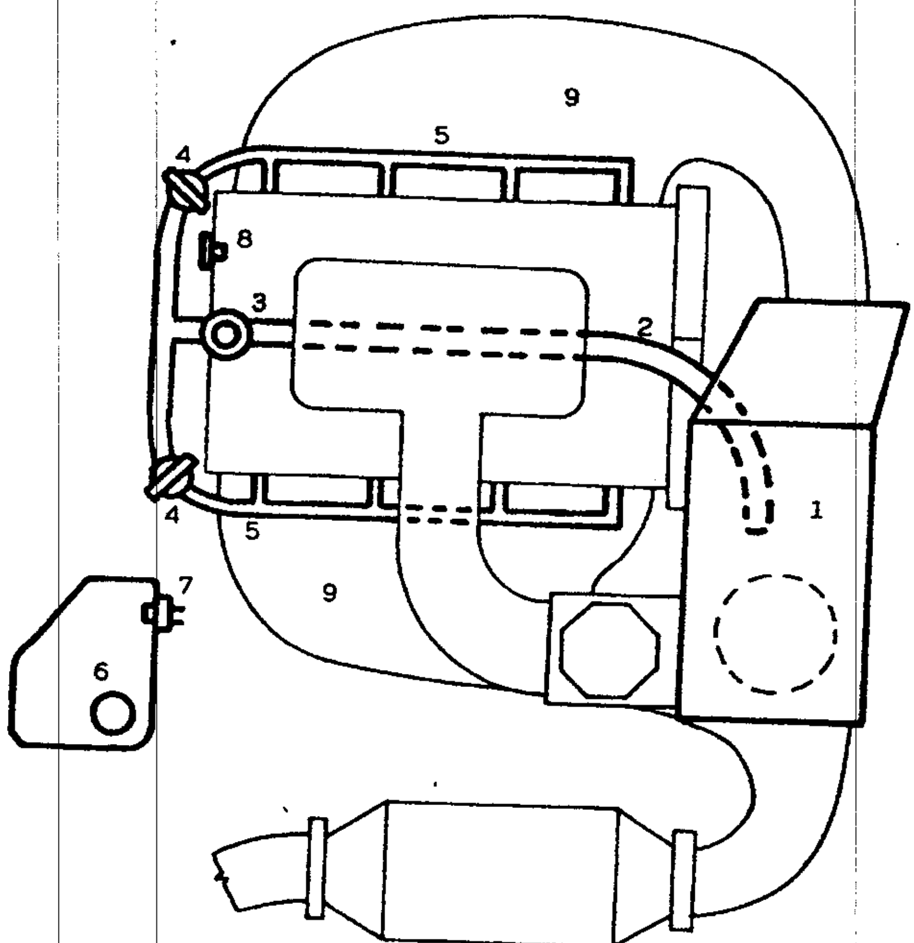
With reference to the general layout, the main components of the system are:

- Pipe (manifolds) for secondary in the engine exhaust parts, downstream the exhaust valves.
- 2 check valves, one for each engine bank.
- One "cut off" vacuum operated valve, closed with no vacuum which opens, when needed, the inlet of secondary air, coming from the engine air cleaner.
- One elctrovalve on the vacuum line between intake manifolds and "cut off valve" open when energized.
- 2 thermoswitches, one for engine oil, one for engine coolant, controlling the vacuum electrovalve (Item 4).

Mode of Operation

Secondary air flow from air cleaner, with "cut off" valve open, is induced into the engine exhaust ports by the ambient exhaust gases pulsations, and prevent air from flowing back during the "pressure" peaks.

Pulse Air Injection System

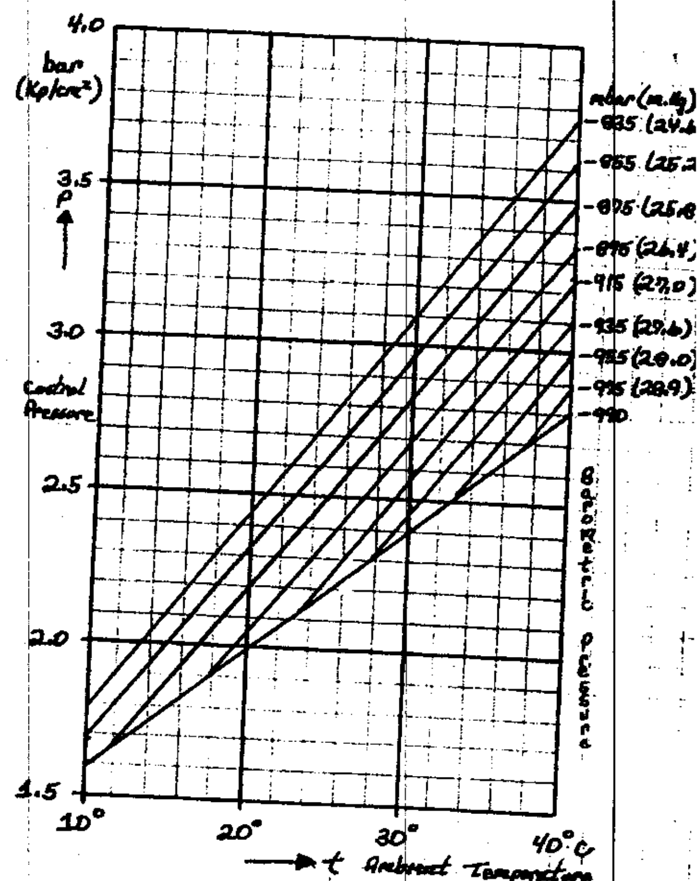


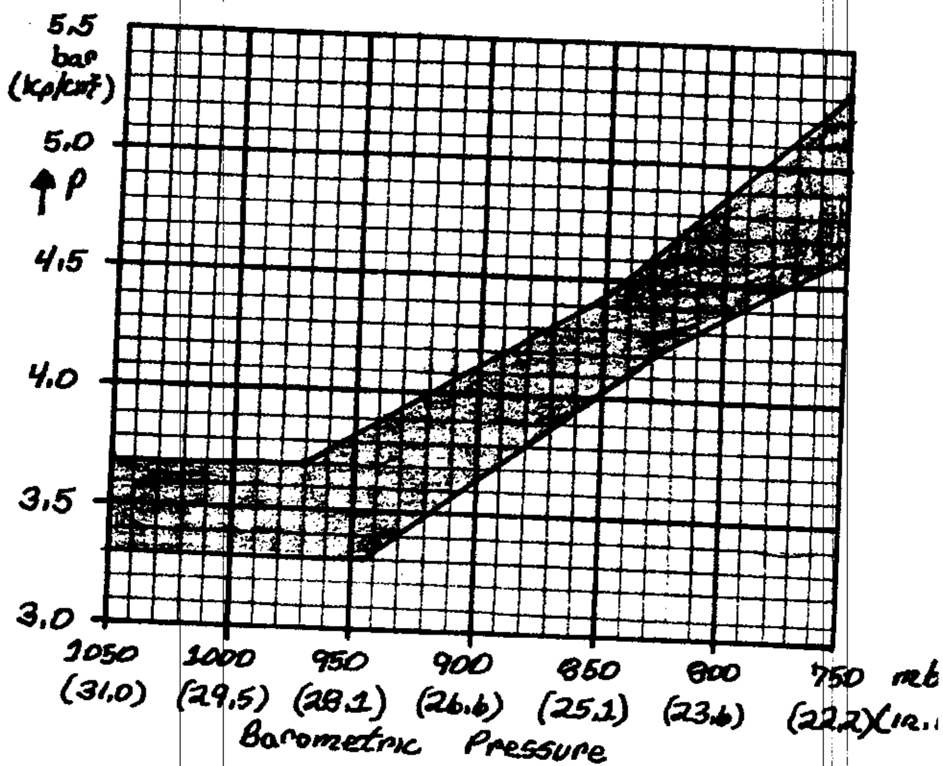
1 = air filter
2 = air to cut-off valve
3 = cut-off valve
4 = check valve
5 = secondary air pipes
6 = engine coolant expansion tank
7 = engine coolant temperature switch
8 = engine oil temperature switch
9 = insulated exhaust manifold

Figure 12

SPECIFICATIONS

.Y. 1984/85 K-Jetronic with Lambda Control, 8 Cylinder Models - U.S. Version

TEST PROCEDURE	TEST DATA
) Fuel pump delivery	Min. 1100 cm^3/30s
) <u>Cold control pressure warm up regulator</u> no. 0438140132 (warm up regulator for altitude compensation) p = Control pressure t = Ambient temperature Pabs = Absolute ambient pressure Compare nominal value of Control pressure corresponding to ambient temperature and ambient pressure to the diagram. <u>A tolerance of ± 0,2 bar</u> is valid for basic control pressure curve. For high values curves of Control pressure, a <u>tolerance of ± 0,25 bar</u> is valid. For ambient pressure value higher than 980 mbar (735 mmHg) the basic control pressure curve is valid.	

TEST PROCEDURE	TEST DATA
p = Control pressure Pabs = Ambient pressure) Warm control pressure Warm up regulator no. 0438140132 (warm up regulator for altitude compensation). Must be tested after stabilizing of the warm up regulator	
Primary Pressure Fuel distributor 043810039 Reading values: Adjusting values	 4,7 ... 5,4 bar (4,8 ... 5,5Kp/cm^2) 4,9 ... 5,1 bar (5,0 ... 5,2Kp/cm^2)
Leakage Test Fuel accumulator no. 0438170004 Residual pressure after 10 min. after 20 min.	 2,7 bar (2,8 Kp/cm^2) 2,6 bar (2,7 Kp/cm^2)
Injection valves no. 0437502010 Opening pressure	 3,0 ... 4,1 bar (3,1 ... 4,2 Kp/cm^2)

ST PROCEDURE	TEST DATA	
Fuel distributor Fuel delivery comparative test		
Fuel distributor no. 0438100139	Set point	Max. permissable fuel delivery
Idle speed	6,0cm^3/min.	6,6cm^3/min.
Partial load	40,0cm^3/min.	43,0cm^3/min.
Full load Check that the delivery of 136,0cm^3/min can be achieved		150,0 cm^{3}min.
Idle speed adjustment - RPM:	1000 $\pm$ 100	
- Co concentration (both banks joined together)	*0,7% $\pm$ 0,15% with oxygen sensor disconnected. Duty cycle with oxygen sensor connected must be: 50% $\pm$ 15%.	
Oxygen Sensor Control function Duty cycles:		
t0 max lean:	< 20%	
t1 Oxygen sensor disconnected:	50% $\pm$ 5%	
t2 Max. rich (at least)	> 87%	
t3 Cold engine oil	(< 25° $\pm$ 3°C) : 65% $\pm$ 5%	

In order to adjust or check idle speed; warm up the engine in driving conditions. Oil temperature approx. + 80°C.

Adjustment and Operating checks needed for Oxygen Sensor; warm up the engine with the sensor connected