FIAT 124 SPIDER

Engine Maintenance and Modification

Bradley Artigue

1st Edition

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Contents

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1. Introduction

Welcome to my guide on FIAT 124 Spider engine maintenance and modification. Spiders are great cars, born in the mid 1960's when sports cars were fun to drive, affordable, and easy to work on. They remain a hobbyists' dream. In 2002 I started to compile the various pieces of knowledge I obtained over the years into guides, first on carburetion and intake/exhaust systems, then, in 2004, a guide (more like a pamphlet) on fuel injection. I revised both guides over the years and finally compiled everything into this single document. My goal is to help you enjoy your FIAT as much as I enjoy mine.

Acknowledgements and great thanks to…

> Jennifer Artigue, who has always supported (or tolerated) my obsession with these cars;
>
> Richard Ridge reviewed this guide several times throughout its development and has been instrumental in reviewing my other works as well;
>
> Eli Caul maintains Mirafiori, the FIAT page (www.mirafiori.com) and has worked tirelessly in his support of the FIAT community;
>
> Andrew Artigue disassembled, rebuilt, restored, and drove many Spiders with me throughout the last ten or so years;
>
> Troy McKaskle performed the final edits on the document and allowed his cars to be as test cases long before any of us claimed to know what we were doing;
>
> Pete Angel supplied diagrams and suggestions and reviewed sections of this document throughout its development;
>
> and Mike Richmond and Thad Kirk who wrote or reviewed sections of my previous works, much of which was brought over to this document.

Thank you for keeping these cars on the road.

bradley j. artigue

September 2007

2. Concepts

This section describes some of the basic things we'll discuss throughout this guide.

2.1 The Otto Cycle

The most common type of operation for automotive engines is the four-stroke cycle, also known as the Otto cycle. Conceptualized in the 1870's by Nicolaus Otto (and others), the cycle has four stages of operation, beginning with the engine at Top Dead Center (TDC), when the piston is furthest from the crankshaft:

- **Intake:** The intake valve opens and fuel and air are drawn into the engine as the piston is drawn down.

- **Compression:** The intake valve is closed and the piston rises, compressing the mixture.

- **Power:** The compressed mixture is ignited, the resulting explosion forces the piston down.

- **Exhaust:** The exhaust valve opens and the spent gases are forced out as the piston rises.

If you want to know more about the Otto Cycle theory and all of the mechanical engineering concepts that are involved pick up a copy of "A Practical Treatise on the 'Otto' Cycle Gas Engine" by William Norris, Longman, Green, and Co., London, England, 1896. At the time of this writing it is available for download on books.google.com. It is a very old book but is wonderful at describing the basic concepts of an automobile engine.

2.2 Lambda

Fuel Injection systems and Carburetors have a common goal – to reach an air to fuel ratio of 14.7:1 and maintain that ratio through changing engine loads. The ratio is known as the stoichiometric air-fuel ratio for gasoline. It is commonly referred to as *lambda*. Any mixture less than 14.7:1 is considered rich; any mixture above is considered lean.

The air fuel mixture is established on a carburetor by setting mechanical devices, such as air bleeders, fuel jets, and emulsion tubes. On a fuel injection system the mixture is constantly adjusted by a computer that varies the amount of fuel sprayed into the cylinder. Both systems rely on a stream of measured air, regulated by a throttle, to deliver atomized fuel into the engine.

2.3 Carburetor

A carburetor is a device that mixes fuel and air together for use in an internal combustion engine. A throttle regulates the amount of airflow into an engine and the subsequent increase in air speed and drop in pressure. A restriction in the carburetor barrel, known as a venturi, forces the air stream to increase in speed as it passes by a number of fuel-delivering orifices. The orifices enrich the stream of air with fuel. The resulting mixture is a near lambda combination of air and fuel.

2.4 Fuel Injection (FI or EFI)

A fuel injection system delivers a metered amount of fuel under high pressure into a stream of air. Unlike carburetion, fuel injection does not rely on the pumping of the engine to draw fuel into the air stream. Instead the fuel is forced through a small orifice (a fuel injector) at very high pressure. The flexibility of fuel injection systems and accuracy of fuel delivery leads to increased horsepower, better atomization of fuel, reduction in emissions, and improved fuel economy.

2.5 Compression Ratio (CR)

The compression ratio is used to measure the performance of an internal combustion engine. The compression ratio is calculated by taking the cylinder bore (diameter), piston stroke, and volume of the combustion chamber prior to ignition. The formula looks like this:

$$\frac{\frac{\pi}{4} b^2 s + V_c}{V_c}$$

Where **b** is cylinder bore diameter, **s** is the piston stroke length, and **Vc** is the volume of the combustion chamber. It is important to note that your author inserted this only to demonstrate use of the pi (π) character and because formulas make guides like this one look more scientific and authoritative.

FIAT Spiders had compression ratios that ranged from a low of 7.5:1 (Spider Volumex) to a high of 9.8:1 (124 Sport Spider 1608). The Volumex relied on a supercharger to increase the horsepower of the engine; therefore, it is notable that compression ratios alone are not the sole indication of an engine's capabilities. Generally speaking, and since most of us would not install (and could not find) a Volumex supercharger on our FIAT, mild increases in CR towards the 9.8:1 range result in good performance increases. CR is typically increased with a piston swap, although other methods (described later in this guide) will bump it up a point or two.

Pistons are available that will drive the CR of the engines upwards, all the way to 11:1. A general rule about compression ratios is that the higher the CR the higher octane fuel you will need to keep the engine from knocking. These days most FIATs are recreational vehicles, and pump-grade 'super' unleaded of 92 or higher octane will satisfy the CR of any stock Spider up to 9.8:1.

2.6 Home Mechanic

Throughout this guide I make references to the "home mechanic." This is, most likely, you. As these cars age finding a qualified professional mechanic is becoming more and more difficult. Spiders are easy to work on and, with few exceptions, will not require any specialized tools to make run correctly. Your best source for diagnostics is yourself; if you must use a professional mechanic arm yourself with the ability to discuss the problem.

2.7 Shop Manuals and Guides

A "shop manual" is referred to many times in this guide. There is only one shop manual for your car, it was originally published by FIAT and is sold by FIAT parts vendors. There were also numerous "guides" published by companies like Autobook, Haynes, Chilton's, and Drake. To avoid any confusion please note that unless explicitly stated, references to the shop manual *always* indicate the FIAT shop manual.

3. Engine Identification

It is important to know what engine, cylinder head, carburetor, intake manifold, and exhaust system you have on your FIAT. Understanding what you have allows you to make an educated decision about what you need. If you are not 100% sure of what you have then take a few moments to check - many have had engine, cylinder head, carburetor, exhaust, ignitions, and all kinds of other parts swapped out. You need to know what you're running in order to get it running right or swap it for the right thing.

The engine identification number is stamped into the engine block near the oil filter. It is sometimes covered in grime. Carburetor cleaner or degreaser and a brush will allow you to read it. On the Spider 2000 engine (1979-1985) it is located just to the right of the oil filter. On all Spiders manufactured prior to 1979 it is located above the oil filter. Check your engine number with the chart on the next page. It is important to note that the last few numbers may not match up - this usually indicates an engine swap at some point in your car's history. If the first digits (i.e. 132A1 is always a 1756) are correct then you have the original displacement engine in your vehicle. If the last few digits (i.e. 031.5) are correct then you have the original displacement and model year type.

Figure 1: Engine Identification

What if you don't have the original engine? This situation is more common than you might think – many owners installed larger motors to gain additional performance, a common swap was the 1608cc for the 1438cc. Others had swaps due to necessity, such as installing a 1978 engine in their 1975 because the original no longer worked. Whether or not a swap was good is something you need to decide for yourself; if originality is your goal then it may be worthwhile to seek out the original parts. If power is more important then it might be worth keeping that 102 HP 1608cc instead of installing a 91 HP 1438cc.

Table 1: Engine Identification Table

Model Year	Series	From S/N	Engine	Displacement
1967 – 1969	124AS	5619	124AC.040	1438cc
1970 – 1971	124BS	21861	124AC.040	1438cc
1971 - 1972	124BS1	33950	125BC.040	1608cc
1973	124CS	59592	125BC.040	1608cc
1973	124CS	63308	132AC.040.3	1592cc
1974	124CS1	71650	132A1.040.4	1756cc
1975	124CS1	88792	132A1.040.5	1756cc
1975	124CS1		132A1.031.5	1756cc
1976	124CS1	99909	132A1.040.5	1756cc
1976	124CS1		132A1.031.5	1756cc
1977	124CS1	113343	132A1.040.5	1756cc
1978	124CS1		132A1.031.5	1756cc
1978	124CS1	126001	132A1.040.5	1756cc
1978	124CS1		132A1.031.5	1756cc
1979	124CS2	142514	132C2.040	1995cc
1980	124CS2		132C2.031	1995cc
1980	124CS2	157654	132C3.040	1995cc
1981 – 1985*	124CS0	171001	132C3.031	1995cc

** Pininfarina Sold the 124 as the "Azzura" and "Spidereuropa" after 1982*

4. Carburetion

FIAT Spiders manufactured from 1967 through 1980 were equipped with carburetors, except in California where the 1980 model year introduced fuel injection. Carburetors were provided by Weber SpA (Italy). FIAT and Weber have a long history; in the 1920s Eduardo Weber began producing carburetors for conversion kits intended for FIAT vehicles. His designs were the first progressive twin-barrel types with one barrel smaller than the other. Various updraft, downdraft, and sidedraft designs were produced by Weber and the carburetors were installed on vehicles ranging from small engine street cars to twelve cylinder racing cars. Weber carburetors are still used today in off-road, racing, and street applications.

4.1 Understanding Carburetors

An easy way to understand how a carburetor works is to study a very simple type, the single-barrel, updraft carburetor. After this brief introduction we'll work through subsequent improvements to arrive at carburetors similar to the one on your FIAT.

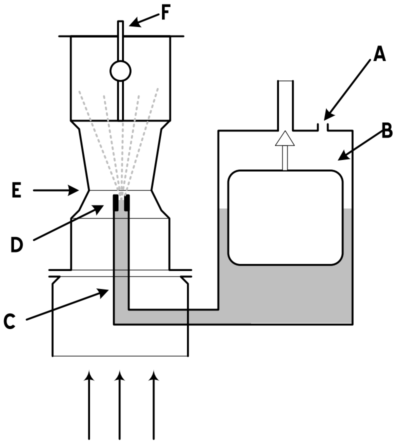


Figure 2: Updraft Carburetor. A Float Chamber Vent , B Fuel Bowl or Chamber, with Float , C Spray Tube, D Fuel Jet , E Venturi , F Throttle

Referring to figure 2, an updraft carburetor has the following features:

- A fuel bowl or chamber (A) in which a float-controlled needle valve keeps the fuel constantly at a level 5-6mm lower than the fuel in jet (D).

- A Venturi (E). The purpose of the venturi is to increase the depression acting on jet (D) to favor the vaporization of the gasoline sprayed from the jet during engine operation.

- A spray tube or nozzle (C) through which fuel flows from float chamber to calibrated jet (D).

- A throttle (F) that regulates the amount of fuel/air mixture drawn in by the engine.

Updraft carburetors were understandably impractical. Carburetors quickly progressed to down draft types, with an important improvement known as air bleed correction.

4.2 Air Bleed Correction

Emulsion tubes mixed air with the fuel prior before entering the carburetor. This air bleed correction (figure 3) made operation more efficient.

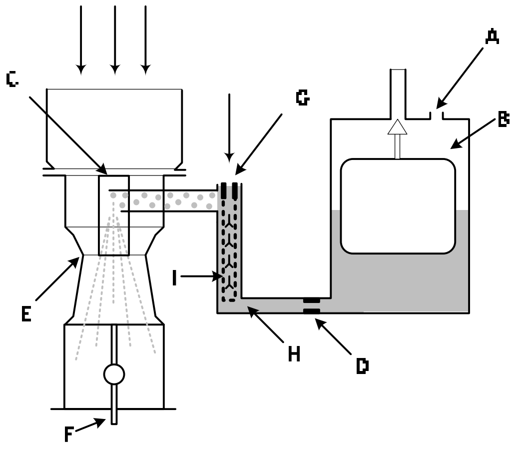


Figure 3: Air Bleed Correction. A Float Chamber Vent , B Fuel Bowl or Chamber, with Float , C Spray Tube, D Fuel Jet , E Venturi , F Throttle , G Air bleed jet, H Well for emulsion tube, I Emulsion Tube

A perforated emulsion tube (I) enables air and fuel to be mixed prior to being sprayed into the carburetor barrel. This results in fuel "misting" into the barrel. The arrangement allows for larger jets and supply tubes and a wider range of tuning. Air enters the emulsion tube through an air bleed correction jet. The jet is removable, allowing for precise adjustment of how much air is allowed into the emulsion tube well. There is one well, emulsion tube, and jet per carburetor barrel.

4.3 Idle Speed Control

An additional improvement is an idle speed device (figure 4). This device allows your engine to maintain the lowest rpm rate at which it will keep running.

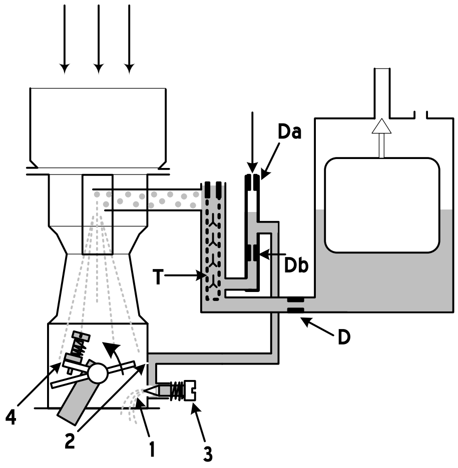


Figure 4: Idle Speed Circuit. D main fuel jet, Da idle speed air jet, Db idle speed fuel jet, 1 idle speed mixture orifice, 2 transition device, 3 idle speed mixture adjusting screw, 4 throttle setting or idle speed adjusting screw

The throttle is nearly closed and fuel is drawn from below the throttle plate, rather than from the main jetting. The idle speed device is an independent circuit on the carburetor, sharing the fuel bowl with the main circuit but having its own mixture setting, jetting, and an idle speed screw to regulate throttle position and engine speed.

4.4 Transition

We've reviewed the main and idle stages of a carburetor, so let's take a look at how your carburetor transitions smoothly from the idle stage to the main stage. In the side of your carburetor barrel are holes, known as progression holes or transition orifices. Movement of the throttle past these holes draws fuel into the engine (specifically, a drop in pressure draws fuel through the holes as the throttle passes), creating additional speed while building up to the main stage.

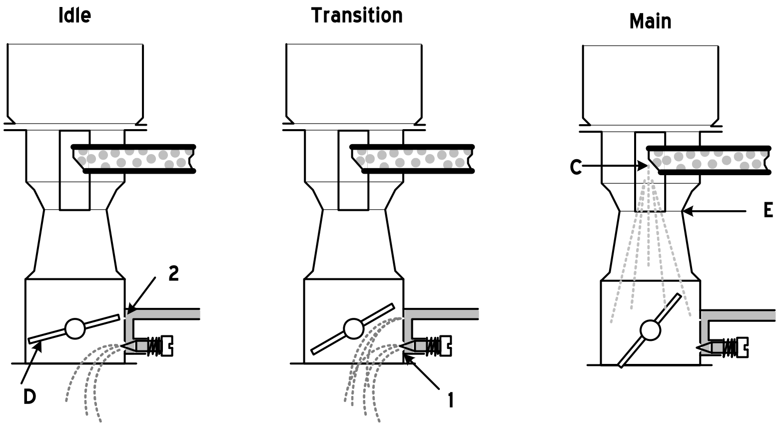


Figure 5: Transition Stage. 1 idle mixture orifice, 2 transition orifice, C spray nozzle, E venturi, F throttle

As the throttle continues to move the idle circuit, fuel feed to the progression holes will cut off, and the engine will run entirely on the main circuit. Figure 5 depicts a carburetor with a single transition orifice; in reality your carburetor may have several to make a smooth transition. Without these holes the engine would stutter between the idle and main stages.

Holes in the side of the carburetor are not enough to keep the transition and power curves smooth. Your FIAT Spider has a "quick throttle," meaning that throttle movements can be fast enough to cause a lean condition. To compensate for this your carburetor is fitted with an accelerator pump, used to inject additional fuel during the transition stage.

4.5 Acceleration Pump

FIATs use a diaphragm-type accelerating pump, as depicted in figure 6. A roller under the throttle mechanicals rests on a plate. When the throttle is moved the plate turns against the roller, causing an arm to press the diaphragm in and force fuel through the pump jet and into the stream of air passing through the carburetor. This richens the mixture of fuel to compensate for the lean condition caused during quick throttle movement.

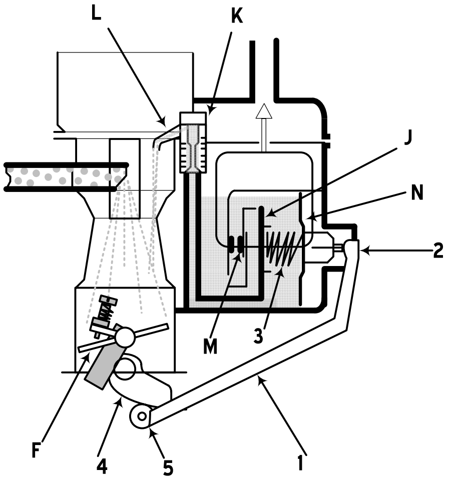


Figure 6: Diaphragm-type accelerating pump – 1 Control lever, 2 Pump spring, 3 diaphragm return spring, 4 Cam lever, 5 Roller, F Throttle, J inlet valve, K Delivery valve, L Pump jet, M pump drain jet, N Pump diaphragm

4.6 Cold Starting

On a cold morning your FIAT may be hard to start. If things are working properly you will do one of three things to set the cold start device. You may pull a knob under your dashboard. This knob is connected to a cable that moves a metal plate over the top of your carburetor. If you have a later model FIAT (specifically those fitted with the ADHA or ADFA carburetor) you might press the accelerator to the floor before starting the car and then release it. This sets a semi-automatic, water-controlled mechanism in place. This mechanism moves a metal plate over the top of your carburetor as well. Finally, you might do nothing, meaning that you have an electric choke on a non-standard carburetor. In case you're wondering the electric choke also moves a metal plate over the top of the carburetor. In all types this metal plate "chokes" the carburetor, restricting the amount of air entering the engine but having no effect on the amount of fuel. This causes a very rich condition, conducive to cold starting.

In figure 7 a simple choke is depicted. A plate moves upward, restricting airflow into the barrel but not fuel. Once engine operating temperature is reached the choke is disabled and normal airflow returns. Improvements in chokes over the years made them more convenient and efficient. An automatic choke will vary the position of the restricting plate as engine temperature increases, until the choke plate is fully open at normal operating temperature. Weber refers to this as an "anti-flooding device" as flooding an engine will occur if a choke is left fully "on" during normal temperatures.

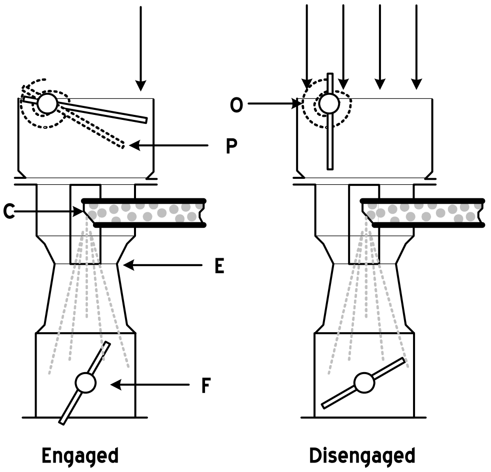


Figure 7: Offset choke, P choke valve, C spray nozzle, E venturi, F throttle, O calibrated spring

4.7 Multi-Barrel Synchronization

We now move into the final discussion on carburetor operation, the multi-barrel carburetor. Multi-barrel - in our case dual barrel - carburetors were designed to solve several problems. Efficient fuel delivery into a four cylinder engine is difficult with one single barrel carburetor. Fitting multiple single barrel carburetors, such as one per cylinder or one per two cylinders would achieve good efficiency but introduce complex (and expensive) throttle assemblies, complicate the fuel line plumbing, etc.

A dual-barrel carburetor provides for sharing of common components, such as the fuel bowl and throttle mechanicals. There is also a single idle circuit in a dual-barrel carburetor, simplifying tuning and making low-speed operation (such as driving in city streets) more efficient. Dual-barrel carburetors work through the synchronization of the throttle plates in each barrel.

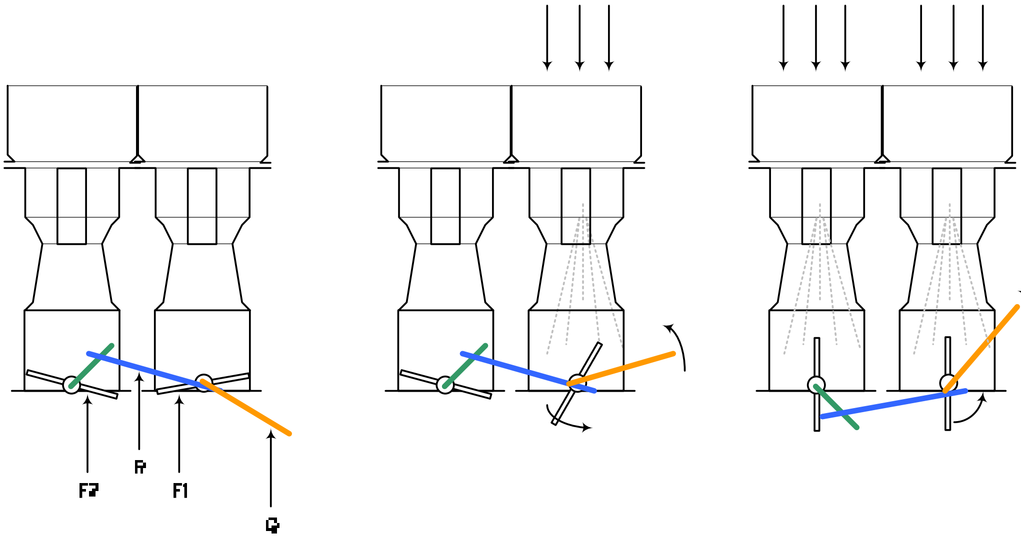


Figure 8: Mechanically controlled differential opening of the throttles. ***F1*** *Primary throttle,* ***F2*** *Secondary throttle,* ***Q*** *Accelerator level integral with primary throttle F1,* ***R*** *Intermediate lever for control of secondary throttle F2*

The synchronization is established through a mechanical or vacuum linkage that activates the secondary barrel when the primary barrel is approximately 2/3 open.

In figure 8, our carburetor starts with the throttles at rest. A throttle arm (A) rotates the primary throttle (F1), bringing the carburetor through idle and progression phases. An intermediate lever (L) is activated at a mechanically set point, connecting the primary and secondary (F2) throttles. As the main throttle reaches wide open throttle the secondary is also fully open, with both barrels running on their main circuits.

A vacuum carburetor (figure 9) achieves the same goal in a different manner. Instead of a lever in between the main and secondary throttles, a diaphragm is connected to the secondary barrel. When a sufficient pressure drop is reached in the primary barrel the secondary barrel begins to open. Progression of the secondary throttle is always controlled by the pressure drop in the primary barrel, making the vacuum carburetor somewhat less “snappy” than the mechanical type.

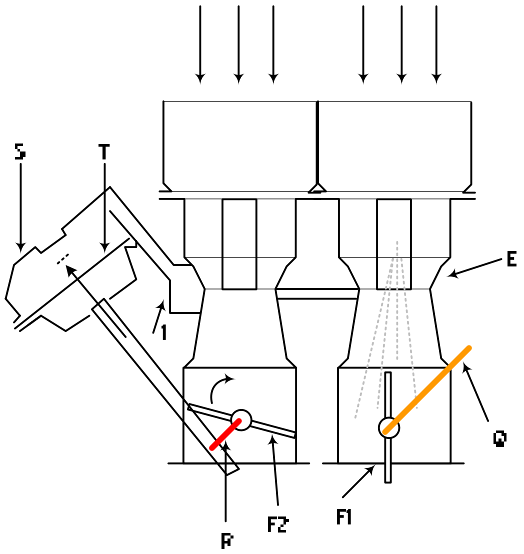


Figure 9: Vacuum controlled differential opening of the throttles – 1 Interconnection between primary venturi E and diaphragm S, E Venturi, F1 Primary throttle, F2 Secondary throttle, S Diaphragm for operation of secondary throttle F2, Q accelerator level integral with primary throttle F1 –R intermediate level for control of secondary throttle F2 activated by the movement of diaphragm T integral to vacuum operated spring mechanism S

4.8 Carburetor Identification and Schematics

Weber stamped an identification number on your carburetor body. Depending on the construction of the carburetor body, this number may be between the middle and lower halves of the carburetor, or on the lowest mounting flange on the "front" (facing the fender) or "back" (facing the cylinder head) side. It may in a different location altogether but should be fairly easy to spot. The number may be quite long, but the primary information is in the first few positions. Figure 10 shows the base of a 1970 Weber 26/34 DHSA1.

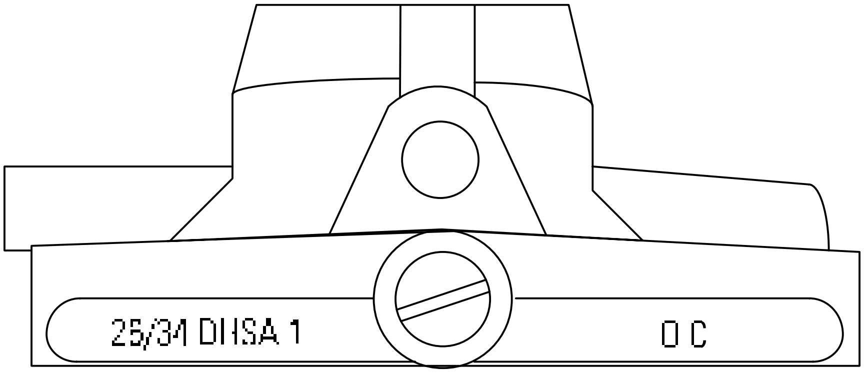


Figure 10: DHSA1 Carburetor Base Plate

Weber nomenclature is not easy to decipher. The important thing to note is the numbers before the letters and the letters themselves. If you read "26/34 DHSA 1 OC" then you can simply note that you have a "26/34 DHSA". The numbers following the letters indicate things like barrel size, factory jetting, emissions control modifications, etc. The variations are minor but almost impossible to track. Using the chart below, note whether or not your carburetor was original equipment on your engine:

Table 2: Carburetor Identification

Vehicle	Year	Displacement	Carburetor
124 Spider	66-67	1438	34 DFH
124 Spider	68-69	1438	26/34 DHSA1
124 Spider	70-71	1438	26/34 DHSA1
124 Sport Spider	71-73	1608	28/36 DHSA2 or 3
124 Sport Spider	71-73	1608	Dual 40 IDF
124 Sport Spider	73	1592	28/36 DHSA2 or 3
124 Spider 1756	74	1756	34 DMSA
124 Spider 1756	75-76	1756	32 ADFA
124 Spider 1756	77-78	1756	32 ADFA
Spider 2000	79-80	1995	28/32 ADHA

4.8.1 Weber DFH

The DFH was used on early production 1438cc Spiders. It is not a common item on cars imported into the United States. The DFH is operationally similar to the DHSA carburetor fitted on later models.

4.8.2 Weber DHSA

The DHSA was used on the 1438 and 1608 motors. Vehicles imported into the United States received the 26/34 DHSA1 and the 28/36 DHSA2. The numbers refer to the primary (26 or 28) and secondary (34 and 36) barrel sizes.

Figure 11: DHSA2 Carburetor

The DHSA is a progressive two-barrel carburetor with a vacuum operated secondary. This secondary throttle opens when the primary throttle is fully open. This opening is controlled by a diaphragm mounted on the side of the carburetor and linked to the secondary throttle shaft (refer to figure 9 in the previous section). The different DHSA models are directly interchangeable with each other and with the DMS and DMSA carburetors.

The DHSA has a mechanically operated choke, meaning that a cable connects the choke plate to a knob. The driver pulls the knob, activating the plate, and restricting airflow into the carburetor.

There are two additional small diaphragms that are electrically activated by the position of the clutch. These devices are also attached to fast idle speed controller, electronically linked to the clutch assembly and to a switch on the transmission. When you shift into or out of 3rd, 4th, and 5th gears the controller keeps the engine speed around 1500 RPM. The actual speed at which the controller engages is set by a switch in the engine compartment.

The diagrams on the following pages show the exploded views of the DHSA carburetor. For a description of the operation of the carburetor refer to the section on the DMSA. The DMSA is operationally similar with the exception of the vacuum secondary.

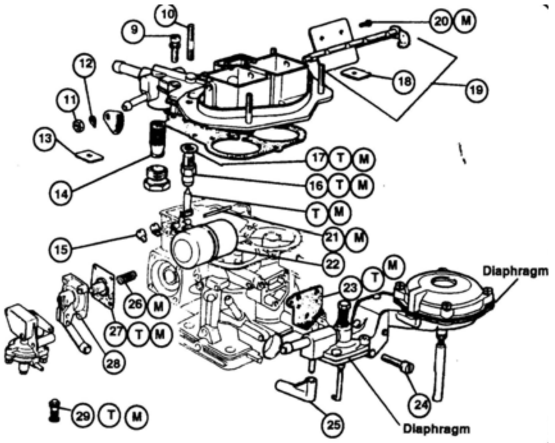


Figure 12: DHSA External Parts, Float Mechanisms, and Choke Assembly

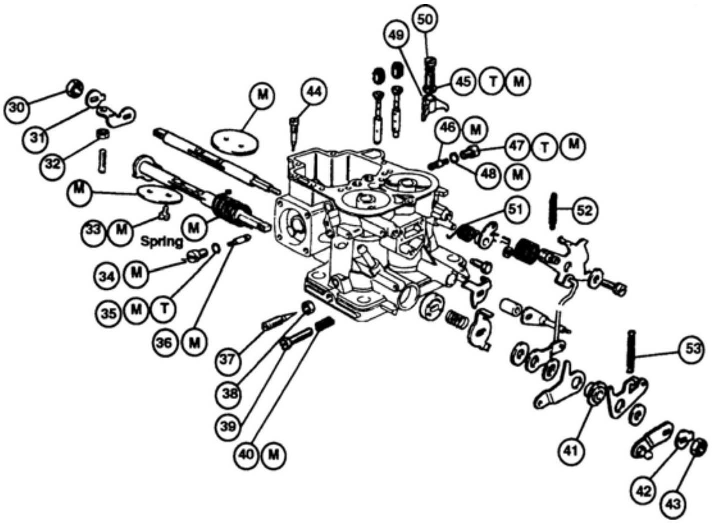


Figure 13: DHSA Jetting, Throttle Mechanisms, and Internal Parts

4.8.3 Weber IDF

European 1608 Sport Spiders produced from 1971 until 1973 were fitted with dual Weber 40 IDF carburetors. Although never an option for U.S. cars many of the manifolds and carburetor pairs were installed on Spiders of virtually every engine displacement from 1608 to 2000. Although no FIAT manifold directly fit the 1438 series, an Abarth manifold was produced that would allow for IDFs on that engine.

The FIAT Abarth Spider CSA (1972), a rare factory produced street version of an Abarth race car, was also fitted with dual IDFs. The actual racing version had dual 44 IDFs carburetors or mechanical fuel injection.

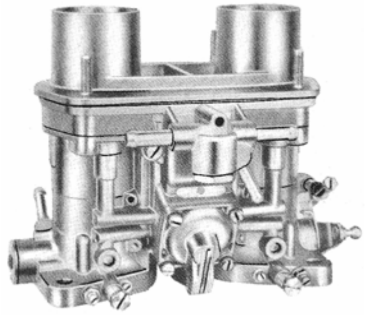


Figure 14: IDF Carburetor Side View

Through needle valve (6) fuel passes into bowl (2) where float (3), hinged on pivot pin (1), controls needle (5) stroke to keep the fuel level constant. Needle (5) is connected to the lug of float (3) via return latch (4).

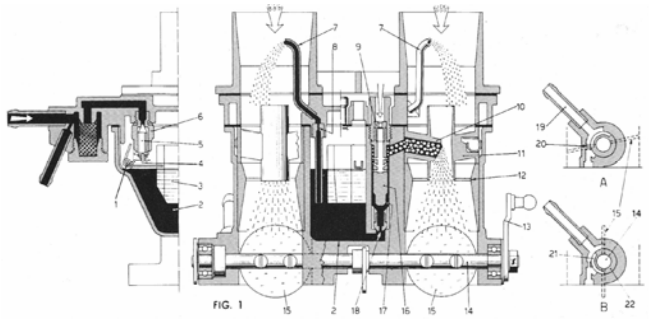


Figure 15: IDF Normal Operation

From bowl (2), through main jets (18), fuel reaches wells (17). After mixing with the air from emulsion tubes (16) and air corrector jets (9), the fuel reaches the carburetion area consisting of auxiliary venturis (11) and main venturis (12) via nozzle (10). The carburetors incorporate a mixture enriching device whose principle of operation is as follows: Fuel is drawn from bowl (2) through calibrated holes in tubes (8) and into the carburetor through spray tubes (7) during high speed operation.

The illustration shows also the crankcase emission control system — diagrams A and B —. The crankcase emission control system consists of a rotary blanking disc (22) driven by spindle shaft (14) controlled by lever (13). Through slot (21) the blanking disc connects blow-by gas tube (19) with the downstream side of butterfly valves (15). Even with butterflies (15) in idling speed position gas suction is controlled by calibrated hole (20).

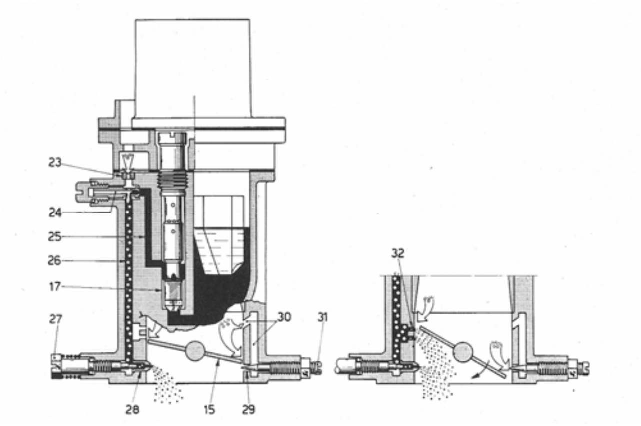


Figure 16: IDF Progression

From wells (17) fuel passes to idle jets (24) via ducts (25). Emulsified with the air coming from calibrated bushes (23) through ducts (26) and bushes (28), adjustable by means of screws (27), the mixture reaches carburetor ducts on downstream side of butterflies (15).

Bushes (28) are calibrated to control idling speed output.

Starting from idle condition, when butterflies (15) are progressively opened the mixture reaches the carburetor ducts via progression holes (32) to bring about an increase in engine angular velocity. To obtain a consistent air feed in both carburetor ducts with butterflies (15) in idle position, a variable volume of air from ducts (30), depending on the position of screws (31), is fed to the downstream side of butterflies (15) through holes (29) situated in alignment with adjusting screws (31).

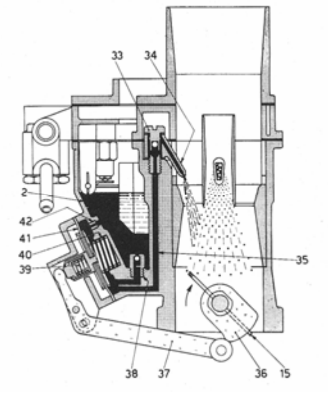


Figure 17: IDF Acceleration

Upon closing butterflies (15) lever (37) frees diaphragm (41) which, under the pressure of spring (40), draws fuel from bowl (2) through ball valve (38).

Upon opening butterflies (15) diaphragm (41) under the action of cam (36) and lever (37) injects fuel into carburetor ducts through ways (35), delivery valves (33) and pump jet nozzles (34). Spring (39) dampens any sudden butterfly opening and prolongs fuel delivery.

The excess fuel delivered by the accelerating pump is exhausted into bowl (2) together with the pump chamber vapours, through calibrated bush (42).

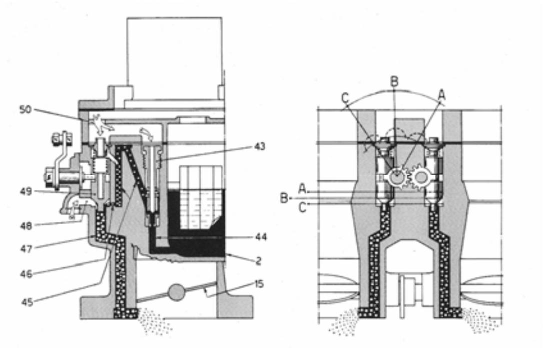


Figure 18: IDF Cold Start Devices

From bowl (2) fuel passes to the starting device through ducts (44) and starting jets (43). Emulsified with the air from holes (50), fuel reaches the recess of valves (49) through ducts (45) and holes (46). Then, completely emulsified with the air drawn from holes

(48), the mixture is conveyed to carburetor ducts on downstream side of butterflies (15) via ducts (47).

Starting with a cold engine - Starting device ON - position A.

Starting with a semi-warm engine - Starting device partially ON - Position B.

Engine warm-up - During this stage, even with the vehicle in motion, disengage the starting device gradually.

Normal operation - Starting device OFF - Position C to be restored as soon as the engine reaches normal operating temperature.

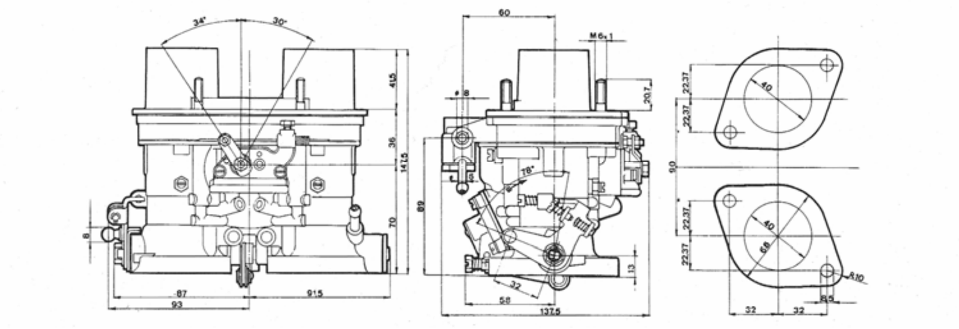


Figure 19: IDF Dimensions

4.8.4 Weber DMSA

The DMSA was used for a single year (1974). It is virtually identical to a DHSA except it lacks the vacuum operated secondary. DMSA has a mechanically-operated secondary and the largest primary and secondary throttles of any carburetor installed on the Spiders. The advantage over the DHSA is there is no time lag during heavy acceleration for manifold pressure to pull open the secondary. The DMSA is a slightly larger carburetor than the DHSA2; this was to accommodate for the larger 1756cc engine introduced in 1974.

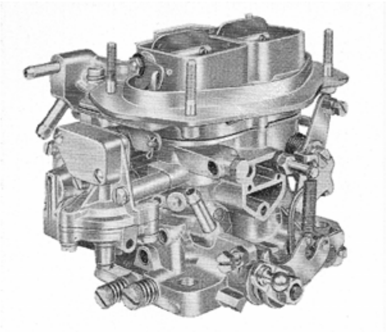


Figure 20: DMS Carburetor Side View

The DMSA and DMS are popular upgrades for DHSA owners. Problems with the vacuum-operated secondary unit (typically stemming from a misunderstanding of how it works) would lead to cars that ran poorly. The DMS, with a direct mechanical connection between the throttle plates, eliminated these problems. As DHSA carburetors wore out they were often replaced with brand new DMS units.

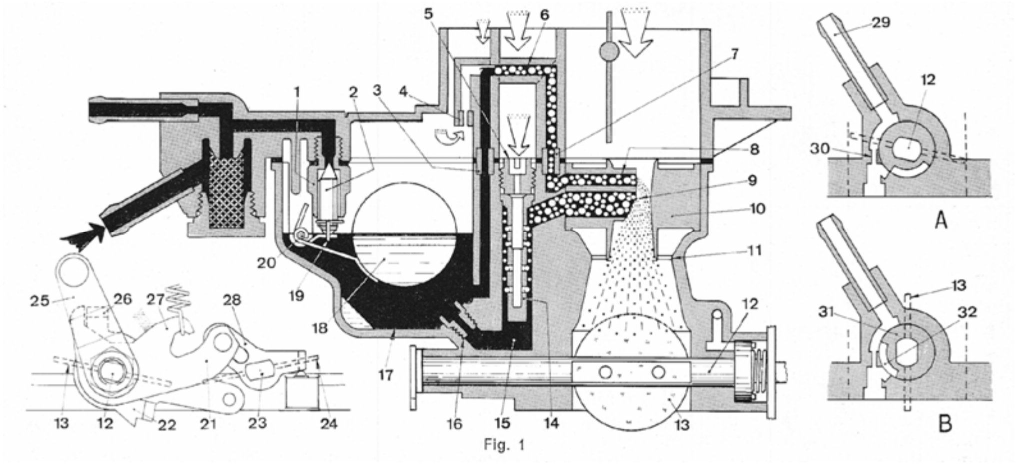


Figure 21: DMS Normal Operation

Through needle valve (1) fuel passes into bowl (17) where the float (18) hinged on pivot pin (20) sets the needle (2) opening to keep level constant: the needle (2) is connected to float tab (18) via return hook (19). From bowl (17) through main jets (16) fuel reaches well (15). After mixing with the air from orifices of emulsion tubes (14) and air corrector jets (5), through nozzles (9) fuel reaches the carburetion area consisting of auxiliary venturis (10) and main venturis (11). This carburetor is provided with a mixture-enriching device on the primary (34 DMS/201) or secondary barrel (34 DMS 1/201 - 34 DMS 2/201): from bowl (17) the fuel metered by a calibrated bush (3) get mixed with the air coming from calibrated orifice (4).

The mixture thus formed through duct (6) and calibrated bush (7) is drawn via duct (8) - into the carburetor primary or secondary barrel during high speed running.

The figure also shows the device for differentiated opening of throttle valves. Upon actuating throttles control lever (25) the tab (26) of the lever plate (22) fixed on primary shaft (12) turns and the primary throttle (13) opens by an equivalent angle whilst the secondary throttle (24) on spindle (23) remains closed.

Subsequently, tab (26) contacts the lug (27) of idle lever (21) which, by shifting the lever (28), rotates the secondary spindle (23) until both throttles are simultaneously wide open.

The figure above also shows the device for gases aspiration from engine crankcase - schemes A and B. It consists of a rotary blanking disc (31) driven by primary shaft (12) which through groove (32) connects the tube (29) - conveying gases to be aspirated - with the area downstream of primary throttle (13). Even with throttles in idle position, conveyance of aspirated gases still takes place and is metered by the calibrated orifice (30).

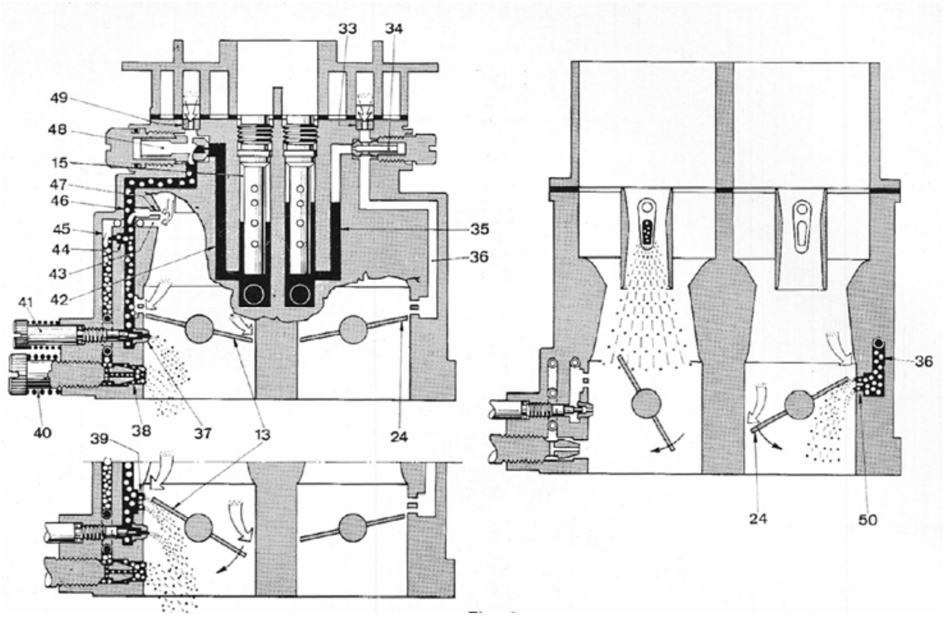


Figure 22: DMS Progression

From emulsion tube (15) the fuel is drawn to idle jet (48) through duct (42): emulsified with the air from calibrated bush (49) via duct (46) it get mixed with the air from calibrated orifice (47) and reaches the carburetor primary barrel downstream of throttle (13) through the calibrated bush (37) adjustable by screw (41).

Mixture reaches the primary barrel also from duct (45) through calibrated hole (44) where it is further emulsified with the air entering from hole (43) and conveyed downstream of throttle (13) via the hole (38) adjustable by screw (40) - (by-pass idling).

Starting from idle rate and gradually opening throttle (13) mixture flows to primary barrel also from progression holes (39) thus allowing a smooth increase in engine angular speed.

When opening the secondary throttle (24), the fuel coming from secondary emulsion tube passes to idle jet (34) through the duct (35): emulsified with the air from calibrated bush (33) via duct (36) it flows to secondary barrel through progression holes (50) placed at throttle (24) level which allow a steady increase in engine angular speed.

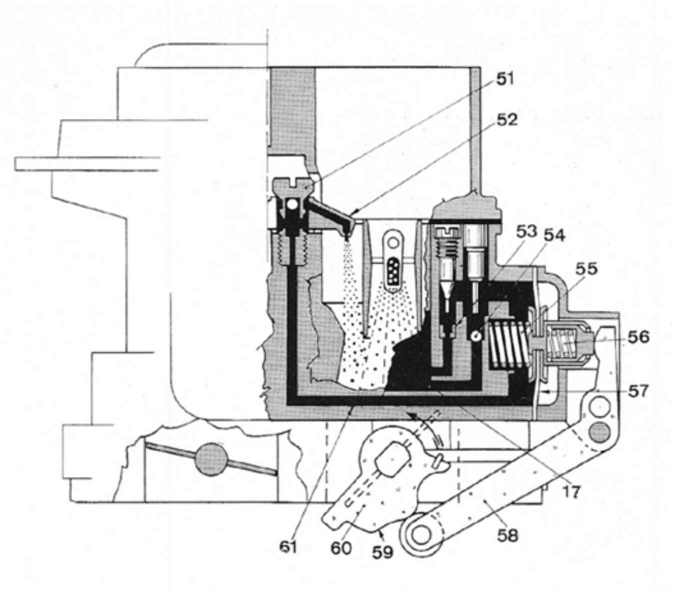


Figure 23: DMS Acceleration

Upon closing throttles, the lever (58) frees diaphragm (57) which through action of the spring (55) draws fuel from the bowl (17) through ball valve (54). Upon opening throttles by means of cam (59) lever (60) and lever (58), the diaphragm (57) injects fuel in carburetor primary barrel via duct (61), delivery valve (51) and pump jet (52). Spring (56) absorbs quick opening of throttles and extends fuel delivery stage. Any excess fuel delivered by the accelerator pump is exhausted into bowl (17) along with pump chamber vapors, through the calibrated bush (53).

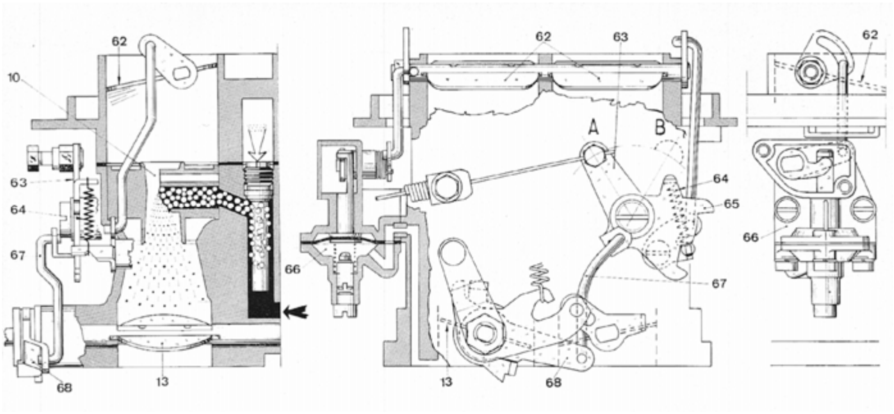


Figure 24: DMS Starting

With lever (63) in position A >, butterflies (62) blank the carburetor air intakes whilst throttle (13) opens partially by mean of rod (67) and lever (68) fast idle.

Thus nozzle (10) delivers a rich mixture allowing prompt engine starting.

Once engine is started, the vacuum acting on butterflies (62) and the action of diaphragm (66) open butterflies (62) partially against action of spring (64).

In these conditions the mixture, still rich, allows normal engine running.

Once engine has reached the rated temperature, disengage the device completely - position B ": butterflies (62) are kept wide open by the lug (65) whilst primary throttle (13) is brought to idle position. Engine starting - engage starting device by pulling knob completely out - position A

Engine warm-up - during engine warm-up, even with vehicle running, disengage the device progressively. Normal running - device off - position B as soon as engine operates smoothly at rated temperature.

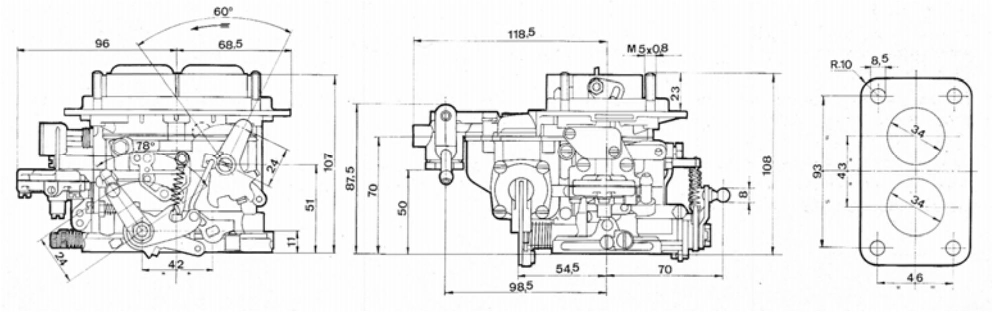


Figure 25: DMS Dimensions

4.8.5 Weber ADFA

The ADFA was introduced in the 1975 model year and used through the 1978 model year. It has a mechanically-controlled secondary and a choke that is controlled by water temperature. This choke is semi-automatic; to activate it the gas pedal is pressed to the floor. If the engine is cold this will release a spring-loaded toothed wheel that holds the choke in place. There is no other manual action required; as engine water temperature increases the spring expands, acting upon the toothed wheel and closing the choke in stages.

Figure 26: ADF Carburetor Side View

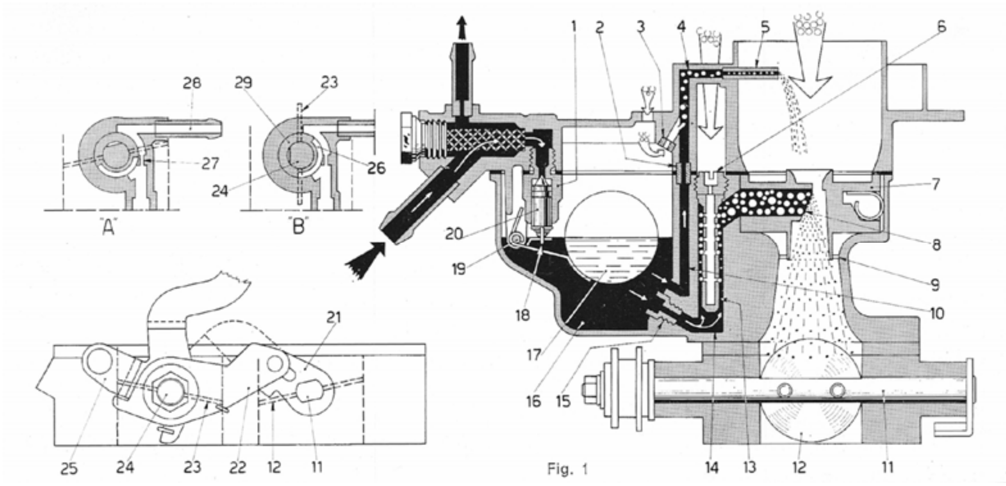


Figure 27: ADF Normal Operation

Through needle valve (1), fuel passes into bowl (16) where the float (17), hinged on pivot pin (19) sets the opening of needle (20) in order to keep fuel level constant: the needle (20) is connected to the lug of float (17) through the return hook (18). The fuel, from bowl (16) reaches wells (14) through main jets (15). After mixing with the air coming from orifices of emulsion tubes (13) end from air corrector jets (6), the fuel reaches, vie nozzles (8), the carburetion area consisting of auxiliary venturis (7) end venturis (9).

The carburetor is provided with the enrichment circuit on second barrel: from bowl (16), the fuel, through duct (10) end calibrated bush (2), blends with the air coming from calibrated orifices (3). The mixture thus formed will be sucked — through duct (4) end calibrated pipe (5) — by the second barrel during full power operation at high r.p.m.

Fig. 1 also shows the device for differentiated opening of throttle valve. Acting on throttles control lever (25), this will first travel a given idle distance: primary throttle (23) — fitted on spindle (24) — will open of a corresponding angle, while secondary throttle (12) — fitted on spindle (11) — remains in closed position. Successively, lever (25) contacts free lever (22), which by shifting lever (21) makes the secondary spindle (11) rotate until contemporary end complete opening of both throttles is reached.

Also shown in Fig. I is the control system for crankcase emission — diagrams A and B. — This consists of a rotary blanking disc (29) driven by shaft (24) controlled by lever (25) which, by means of groove (26) — diagrams A and B — connects pipe (28) conveying gases to be sucked, with the area downstream of throttle (23).

Even by throttle (23) in idle position — diagram A — goes on conveyance of sucked gases metered by calibrated orifice (27).

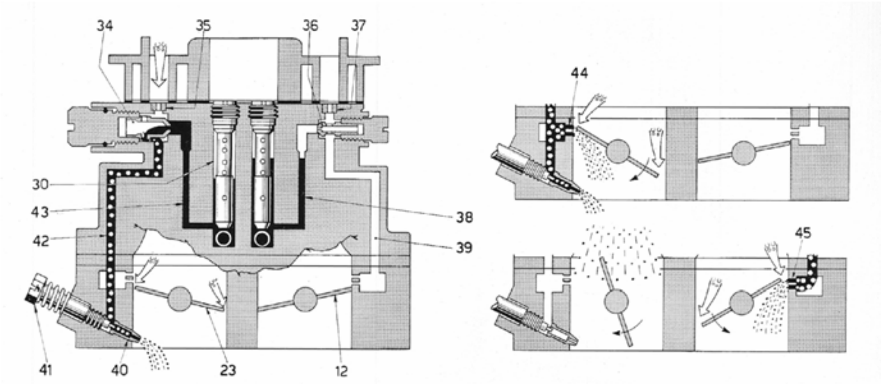


Figure 28: ADF Idle Speed and Progression

From primary well (30) fuel reaches idle jet (34) through duct (43): after emulsifying with the air coming from calibrated bush (35), it flows through duct (42), calibrated bush (40) — adjustable by screw (41) — and reaches the primary throat downstream of throttle (23). The mixture reaches the primary duct also through progression holes (44) near the primary throttle; this allows a smooth increase in engine angular velocity starting from idle running.

By opening of secondary throttle (12), the fuel coming from the secondary well flows to idle jet (36) through duct (38); after emulsifying with the air coming from calibrated bush (37), it reaches, via duct (39), the secondary throat through progression holes (45).

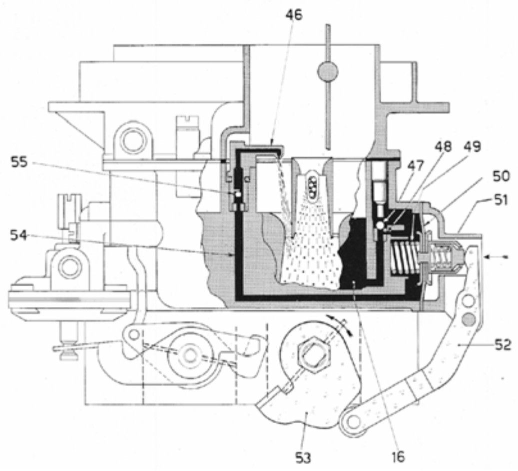


Figure 29: ADF Acceleration

Upon opening of throttles, the diaphragm (50), under the action of cam (53) and lever (52), injects fuel into primary carburetor throat through duct (54), delivery valve (55) and nozzle (46).

Spring (51) absorbs quick throttle opening and allows regular feeding from jet (46). Any excess fuel delivered by accelerating pump, together with pump chamber vapors, is exhausted into bowl (16) through calibrated orifice (48). Upon closing throttles, lever (52) sets free the diaphragm (50) which draws in fuel from bowl (16) through ball valve (47), under the action of spring (49).

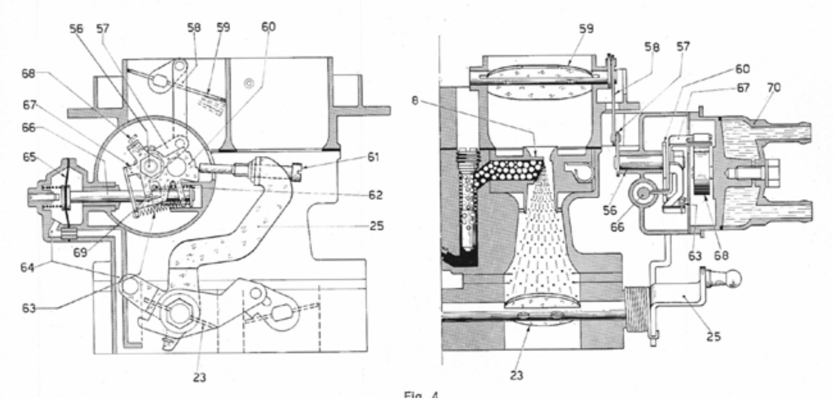


Figure 30: ADF Starting

The choke is of semi-automatic type: this means that to insert it when engine is cold, it is necessary to depress the accelerator pedal completely, then to release it slowly to normal position.

Once the starting device is inserted, the bimetallic coil (68) — via lever (67), spindle (56), lever (57) and rod (58) — keeps the choke plate (59) closed. At the same time, the cam lever (60) will be in the position as shown in Fig. 4 and, by means of lever (25) — adjustable by screw (61) — it will keep the primary throttle (23) partially open (fast idling).

In these conditions, the nozzle (8) delivers a given amount of mixture which, diluted with the air controlled by starter plate gape, allows a quick starting of the engine.

After starting, the vacuum set up beneath throttle (23) through duct (64), acts on diaphragm (65) which being displaced by rod (66) and bush (62) the latter held by the spring (62) make the lever (67) rotate against the action as the bimetallic coil (68) which, via spindle (56), lever (57) end rod (58), will partially open the starter plate (59) thus supplying a mixture strength suitable to allow a normal engine running.

Should the accelerator be depressed when the choke is included, the screw (61) would disengage the cam (60) which drawn by spring (63) would reduce the opening of primary throttle (23).

The engine cooling-water warms up, and, circulating in the cover (70) heats the bimetallic coil (58) which will make the lever (67) turn and through the above mentioned linkage system, will cause the progressive opening of choke plate (59). During rotation of primary throttle (23), the cam lever (60) will also rotate thus excluding progressively the choke.

Once running temperature is reached, the choke plate (59) will be in fully open position: the screw (61) is now no longer in contact with the cam (60) thus allowing primary throttle (23) to close up till to normal idling position.

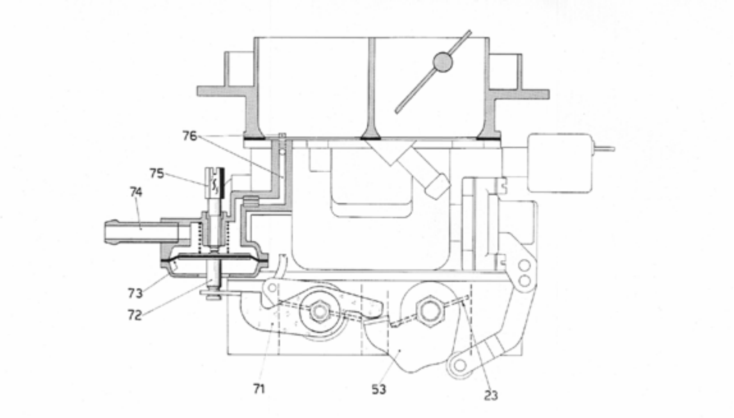


Figure 31: ADF Anti-Pollution Device

ADF type carburetors, provided with vacuum devices to reduce air pollution, are fitted on cars equipped with electric switches that set off a special electro valve located between intake manifold and fuel inlet pipe (74).

The vacuum, through pipe (74), acts on diaphragm (73) which, by means of rod (72), lever (71) and lever (53), opens primary throttle (23) to fast idle position: adjustment of throttle (23) opening is carried out through adjusting screw (75).

Under such opening conditions, during motoring over, exhaust emission levels are rather low; within the air pollution tolerances. When vacuum is intercepted by the electro valve, the air sucked through duct (76), nullifies vacuum acting on diaphragm (73) and allows throttle (23) to return to normal idling position.

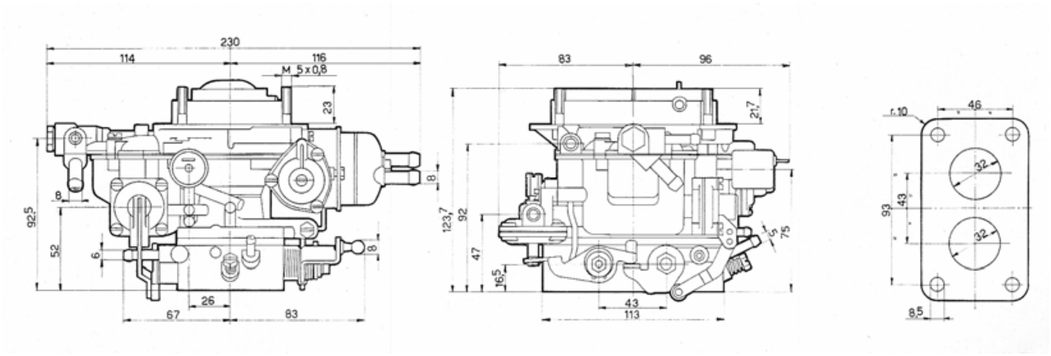


Figure 32: ADF Dimensions

4.8.6 Weber ADHA

The ADHA is similar to the ADFA except for the secondary barrel, which is vacuum controlled. This is a hard carburetor to love. Introduced with the 2000cc engine the ADHA was a small carburetor on the largest of the Spider motors. Although a carburetor with 23mm and 32mm barrels should be adequate for a 2 liter motor, the jetting, intake manifold, and array of pollution control devices both on and off of the carburetor resulted in a fairly uninspiring driving experience.

4.9 Carburetor Tuning

These are the recommended procedures per Weber with some modifications, you will find the same general steps in any publication on setting up carburetors. Should the engine fan come on during these steps STOP working (leave the engine running) until it shuts off. Fans draw current from the alternator, creating a load that will reduce engine speed and may cause you to make incorrect adjustments. Fans are also dangerous to work around.

4.9.1 Set Carburetor to Factory Settings

Back out the idle speed screw until it is no longer in contact with the throttle stop lever. Now turn the screw until it contacts the lever and again 1 ½ turns.

Turn the idle mixture screw (on our carburetors it is typically in the center bottom of the carburetor body) in until it is fully seated - do not force the screw. Now turn it back out two full turns.

4.9.2 Start and warm the Engine

Disengage or block the choke open. On automatic chokes you can use a small clamp or wire to pull the choke mechanism open. The engine should start and run poorly (if it does not remain running then increase the idle speed screw ½ turn until it does). Adjust the idle speed screw until the engine runs at approximately 900 RPM.

Let the engine warm up to operational temperature. On a Spider you will typically wait until the fan has cycled two times (on-off-on-off). Turn the mixture screw in (lean the mixture). If the engine increases in speed then continue to turn until it is no longer increasing or runs worse, then back the screw out ½ turn. If the engine decreases in speed then turn the screw out until it is increasing in speed. Continue to turn until it is no longer increasing or runs worse, then turn the screw in ½ turn. Adjust the idle to approximately 850 RPM.

4.9.3 Final Settings

Set the idle speed screw so that the engine runs at 850 RPM, or 900 RPM if you have air conditioning. Recheck the mixture screw by turning slightly in then out. Engine speed should be set - using the mixture screw ONLY - to the fastest and smoothest point of operation (listen for exhaust popping). Reset the idle speed screw as necessary.

Drive the car under various loads (idle, cruise, hard acceleration, gradual acceleration, etc.) for a short period of time then remove one of the spark plugs. The electrode should be brownish-white in color. A white plug results from an engine that is too lean; a black plug from one that is too rich. Adjust the mixture screw slightly to compensate.

4.10 Diagnostics and Troubleshooting

4.10.1 Air Input Diagnostics

The only source of air entering the engine should be through the carburetor barrels. Air entering the engine through a broken gasket or carburetor spacer can cause poor running. You can spray carburetor cleaner around the base of the carburetor; there should be no change in engine speed. Also check the tightness of the bolts holding the carburetor to the manifold, they should be tight (but not so tight you're bending the base plate!).

If you find that air is entering around the throttle assembly then you might have throttle rods and bushings that have worn themselves out. The carburetor will need to be rebuilt or replaced. Also inspect the carburetor body for any cracks or leaking fuel. Cracks can let in air and typically require the carburetor to be replaced.

4.10.2 Mixture Problems

If problems appear to be stemming from the fuel mixture there are a few areas to diagnose, all of which deal with the basic air/fuel mixture settings on the carburetor.

Always too lean

If the vehicle runs too lean, even with the mixture screw "all the way out" (meaning to the limit of reasonable travel, or about 4-5 turns) then you may have idling jets that are too small. Consider increasing the idle jet size by adding 10 to the size (if you had a 45, increase to 55) then re-set the mixture. Continue up (or down) in increments of 5 or 10 if this appears to be helping.

Always too rich or very limited adjustment range

If the vehicle runs too rich, even with the mixture screw "all the way in" (seated) then you may have idling jets that are too large. Consider decreasing the idle jet size by subtracting 10 from the size (if you had a 55, increase to 45) then re-set the mixture. Continue down (or up) in increments of 5 or 10 if this appears to be helping. Also apply this procedure if your mixture is correct by barely moving the mixture screw open as this will limit your ability to tune the mixture.

Idles with mixture screw seated

If your carburetor idles with the mixture screw fully seated then the car is idling on the main throttle and not on the idle jets. Reset your throttle linkage by using the procedure described in the tune-up section. If this fails to solve the problem then observe your carburetor spraying fuel during operation and look for leaks. The accelerator pump may be leaking into the main barrel during idle operation, causing enough fuel to mix (and mix poorly) to maintain idle.

Poor transition / flat spots in acceleration

During acceleration the transition between the idle, progression, and wide-open stages should be smooth. If not then your secondary idle jet, main jet, or secondary jet may be too small, causing a lean condition in between stages. If you are running a stock carburetor on a reasonably stock engine then check that the jets meet or in the same basic range as was stock for your model year.

Puffing and mild backfires

The mixture can cause puffing and mild backfires at or outside of the idle stage. If you are having these issues then open the mixture screw 1/8 turn and note any change. This will slightly richen the mixture and may eliminate these lean conditions. Continue in 1/8 increments until you've reached a full turn, if there is no difference then reset and check the timing, adjusting as necessary.

5. Fuel Injection

FIAT Spiders manufactured from 1967 through 1978 were equipped with carburetors. Vehicles manufactured from the 1980 model year through the end of production in 1985 were equipped with electronic fuel injection. There is some argument about the transition from carburetion to fuel injection. The most plausible story is that FIAT first offered fuel injection as an option, then as standard equipment in California, then as standard equipment for the entire line. Regardless of when or why you can always tell what system your vehicle had installed by looking at the body style number. This is the first four or five positions in your vehicle's VIN number. The VIN is stamped in your engine compartment, on a small metal plate on your dashboard (near the driver's side windshield), and on some models inside the driver's side door. The first three positions will read "124" or (on later vehicles) "ZFA124", followed by a two letter "primary" body code.

AS, BS, CS1, CS2:	Carburetion
CS0, DS:	Fuel Injection
VX:	Carburetion / Supercharger

Fuel injection systems were provided by Bosch GmbH ("Bosch"). Carburetion and fuel injection approach mixing fuel and air in very different ways. Simply put, a carburetor mixes fuel outside of the combustion chamber. The mixture is drawn through a plenum into the combustion chamber. In a carburetor the settings that govern the mixture of fuel and air remain relatively static, fixed mechanically by the jets and orifices in the carburetor and when the vehicle is tuned. A fuel injection system sprays metered fuel directly into the manifold at the intake port during the intake cycle. The Bosch system used in a FIAT electronically controls the amount of fuel, resulting in more dynamic control of air to fuel ratios.

By the end of the 1970's fuel injection systems were slowly overtaking carburetion on the drawing boards of automotive engineers. Driven by emissions control regulations and a noticeable improvement in performance and fuel economy, fuel injection was evolving from complex mechanical systems to electronic "engine management" systems. The Bosch L-Jetronic system was used on the majority of European fuel injected cars, including FIAT, Alfa Romeo, Ferrari, Lamborghini, Lancia, BMW, Mercedes, Porsche, Renault, Volkswagen, and Peugeot. It was preceded by a number of mechanical systems, including the K-Jetronic by Bosch and mechanical systems by

SPICA, Kugelfischer, and others. Unlike its predecessors, L-Jetronic had an electronic brain controlling the injector pulse and numerous sensors telling the brain what the fuel system was doing. It is superseded by Bosch Motronic. Unlike Motronic, L-Jetronic is not as tightly integrated with the engine; one could consider L-Jetronic a "bolt-on" fuel injection system where Motronic is more "engineered in" to the engine design.

Bosch has always been a leader in fuel injection worldwide because of its association with Mercedes and their leadership with diesel and aircraft engine design. Bosch began developing electronic fuel injection in the 1950s and licensed some early American designs as well. Bosch introduced electronic control to its production fuel injection designs in 1974. A more sophisticated and reliable system, the L-Jetronic soon emerged. An oxygen sensor followed and was quickly adopted by European car makers including FIAT who were struggling to make small high performance engines meet the 1980 California and 1981 U.S. Federal emissions requirements.

5.1 Fuel injection Basics

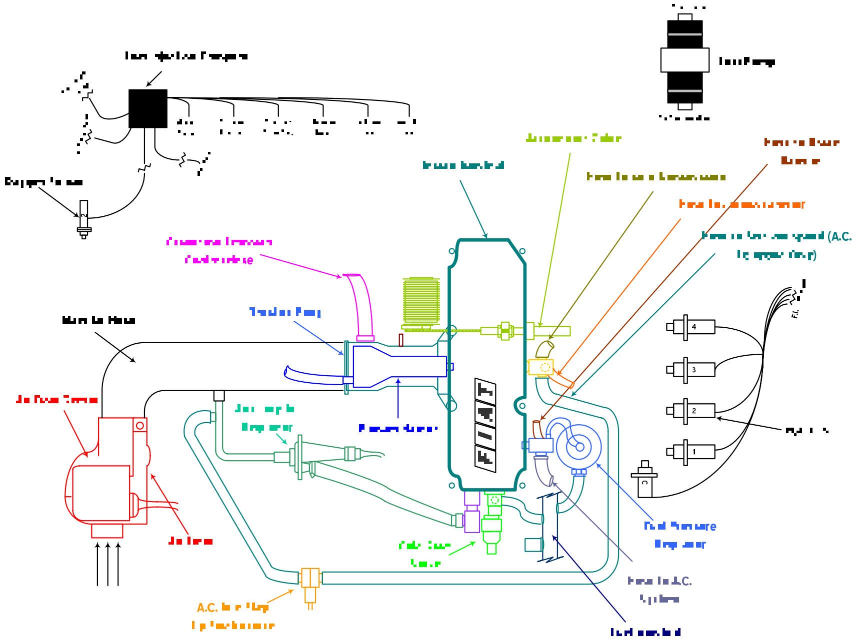


Figure 33: Bosch L-Jetronic Fuel Injection as used in the FIAT Spider 2000.

The FIAT implementation of the Bosch L-Jetronic fuel injection system is relatively simple and uses the most basic components required to operate the system. Many additional options including atmospheric pressure sensors, knock sensors, and crank angle sensors, are all possibilities with L-Jetronic but were never installed. FIAT quite literally built a system around the existing 2000cc carbureted engine. The simplicity results in a system that is inexpensive, easy to diagnose, and can be repaired by the home mechanic. The system consists of a number of components that are located in the engine and passenger compartments. Figure 33 summarizes the major components and some of their connections.

5.2 The Air Flow Meter and Fuel Pump

The air flow meter is positioned just above the air filter and is the only point of entry for air into the fuel injection system. Inside is a spring-tensioned flap connected to a rheostat. As intake air volume increases the flap moves an arm against the rheostat. The rheostat converts the movement of the flap into an electrical current that is sent to the fuel injection computer and is the primary input in the system. Fuel is delivered in proportion to the volume of air and the fuel injection computer adjusts the fuel delivery to best find the 14.7:1 air to fuel ratio.

The stream of new air passes through the main air hose (also called the “big air hose”), connecting to the throttle body. The operation is abbreviated as follows:

1. Air passes the throttle plate into the plenum (the square aluminum box on the engine intake side) and is drawn through runners (pipes under the plenum) into the engine.

2. The fuel injection computer opens the injectors and sprays fuel into the intake runners (the four tubes between the plenum and the cylinder head). All four injectors fire at the same time.

3. Valves open and draw the mixture into the combustion chamber.

4. The mixture is compressed and explodes via ignition spark.

5. The mixture is expelled.

6. An oxygen sensor measures the amount of unburned oxygen in the exhaust.

7. The F.I. computer uses the reading from the oxygen sensor to adjust the next mixture.

The air flow meter also activates the fuel pump. Unlike the 3-5psi pumps of carbureted engines, fuel injection pumps must produce the high pressure that forces fuel into a mist while passing through the injector bodies. The pump fitted to the FIAT 2000 engine produces between 50 and 80psi, which is controlled to between 36 and 43psi by the fuel pressure regulator. As air passes through the air flow meter a chrome rod closes a circuit that activates the fuel pump. So long as air is passing through the meter the pump will run; once the vehicle stops drawing air the pump will shut off.

5.3 Cold Starting Components

Let's discuss the fuel injection components that are used during cold-starting of an engine. When a cold engine is started it requires substantially more fuel than a warm engine. This is due to condensation of the fuel in the air/fuel mixture. A device called a thermo-time switch (see Figure 34) is located directly under the Spider intake manifold. This switch determines the length of time the cold start valve, remains on. The cold start valve is a fifth injector, inserted into the side of the plenum. This injector sprays fuel directly into the air entering the plenum. This rich mixture remains until the engine reaches a temperature sufficient to eliminate condensation of fuel and keep the engine running. This process takes from 2 to 8 seconds depending on the coolant temperature.

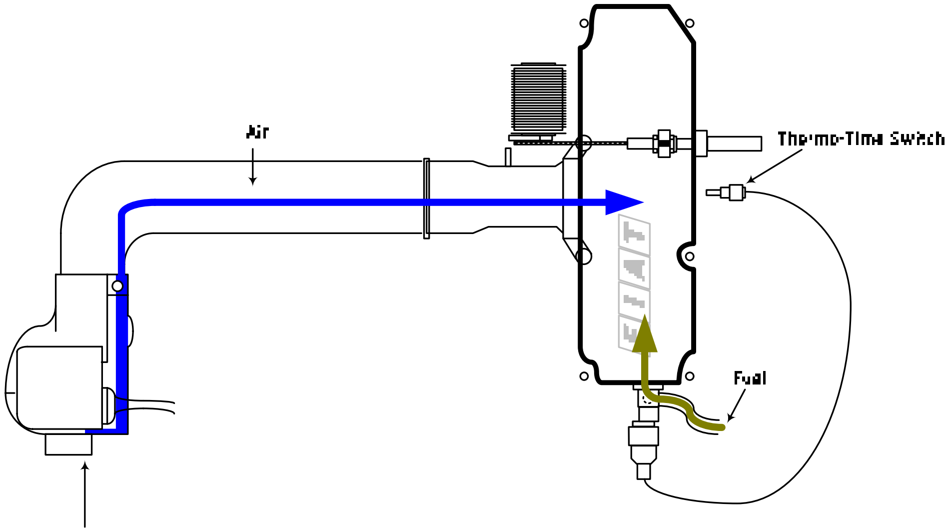


Figure 34: Cold Start Operation in the Bosch L-Jetronic System

5.4 Warm-Up Components

The warm up phase starts when the thermo-time switch heats up and closes the cold start injector. The engine temperature sensor, located in the water coolant "T" in front of the cylinder head, sends coolant temperature readings to the fuel injection computer. The engine is still cool enough to have increased frictional resistance and, without additional fuel and an increased idle speed, will stop running. To compensate the fuel injection computer turns on a device called an auxiliary air regulator. This device allows air to be drawn directly into the plenum, bypassing the throttle plate. The effect is an increase in idle speed – the computer will give the engine more fuel to create an appropriate ratio to the inbound air. Once engine temperatures reach the normal operating range the auxiliary air valve closes. The engine now enters a "normal" operating phase, with no cold or warm up devices operating.

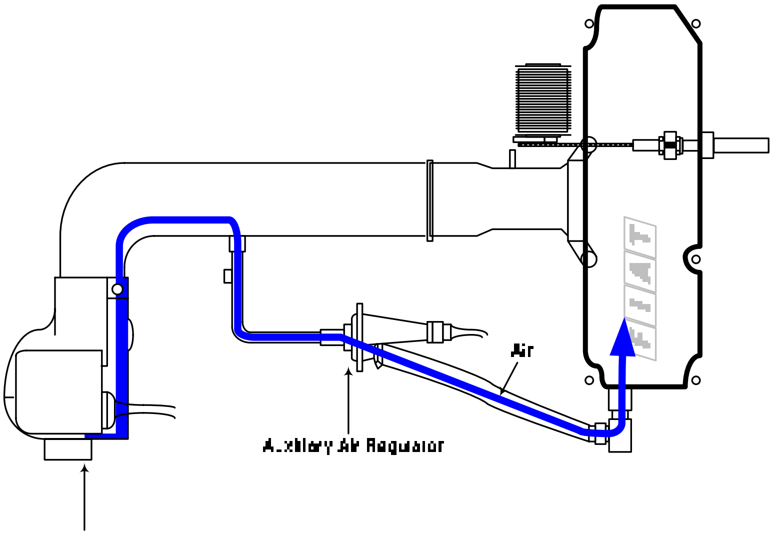


Figure 35: Warm-up Operation in the Bosch L-Jetronic System

5.5 Idle Speed Control Components

Your FIAT fuel injection system maintains idle by allowing a small amount of air to bypass the throttle plate and enter the throttle body. This amount of air is controlled in three ways. First, the mixture is statically controlled by turning a bypass screw on the air flow meter body. Next, the air strikes the throttle plate, which at rest is open approximately 1 degree and allows a small amount of air into the plenum. Additional airflow is directed through a passageway above the throttle and controlled by a needle valve. In this way a fixed amount of air is allowed into the engine at idle, and that volume of air is easy to adjust and control. This operation is depicted in Figure 36.

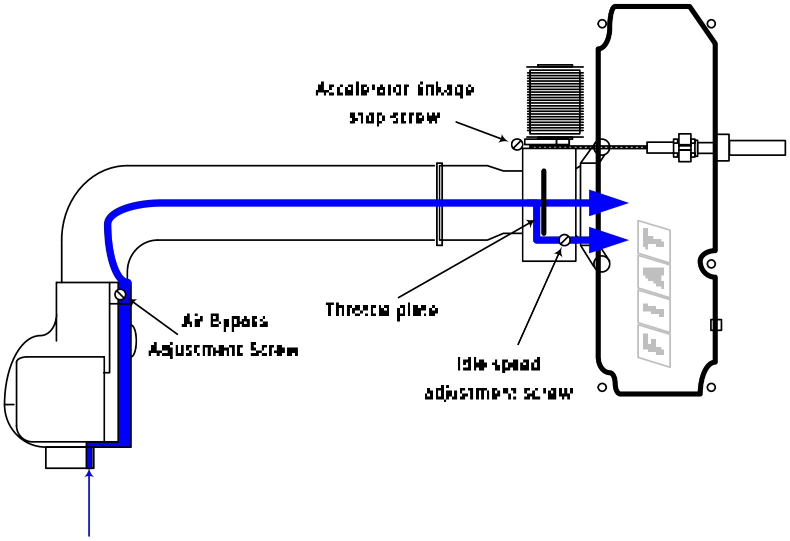


Figure 36: Idle Speed Control in the Bosch L-Jetronic System

5.6 Cruising, Accelerating, and Deceleration Modes

Normal driving conditions are typified by acceleration, cruising, full load, and deceleration. During acceleration additional fuel is injected into the engine. This amount of fuel is governed by the amount of air entering the air flow sensor. Heavy acceleration (wide open throttle) results in a somewhat rich mixture while deceleration results in the fuel injectors being shut off. During cruising the fuel injection computer calculates fuel delivery so that consumption is low. The fuel injection computer keeps the mixture at the leanest point of efficient operation. During each of these phases air temperature is measured by a sensor in the air flow meter. Because air temperature has an effect on the amount of fuel required to maintain good operation, the fuel injection computer will use this input to alter the amount of fuel.

Fuel mixture management is based on optimum masses (weights) of the air/fuel combination. It is not a measure of volume. L-Jetronic systems use the air flow meter to estimate the air mass entering the system by measure air pressure and temperature. During acceleration the air pressure against the air flow meter flap increases, signaling the computer to increase the amount of fuel. The system will also increase or decrease the amount of fuel based on the temperature of the air entering the system.

5.7 The Oxygen Sensor

A final sensor performs continuous monitoring of the exhaust gases. This input is used by the computer to adjust fuel flow to best reach lambda. The oxygen sensor, also known as a lambda sensor, is a ceramic and platinum electrode. The ceramic permits diffusion of the oxygen present in the air. At engine operating temperatures it becomes conductive; when the level of oxygen on one side of the electrode is different from that on the other side a voltage is generated. This voltage is reported back to the fuel injection computer. Sensor operation becomes effective at temperatures above 350 degrees Celsius; below this range the fuel injection computer receives no meaningful input. Many vehicles employ heated oxygen sensors that output data to the computer much faster; the FIAT uses the unheated type.

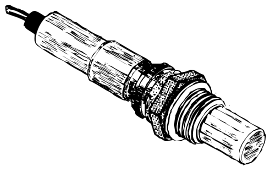
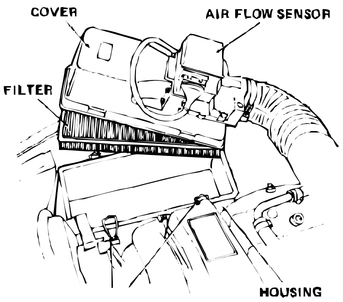
5.8 Other Components

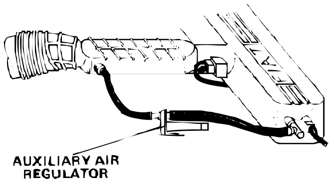
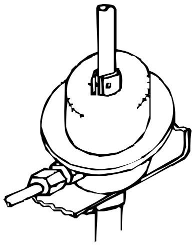
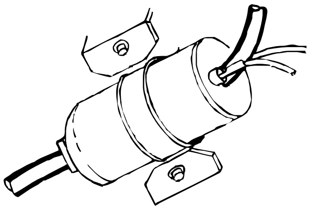
If you flip back to the overview diagram (figure 33) you'll notice a number of other fuel injection pieces and parts that we did not cover. Some of them, such as the air conditioner bypass valve, exist to provide extra air into the plenum when a load (such as the a/c compressor) is switched on. Rarely do FIAT Spiders even have this valve, but if you have the aftermarket air conditioner it may be fitted. You'll also notice the fuel delivery components, the fuel pump, fuel filter, fuel manifold, and fuel pressure regulator. These are responsible for fuel delivery (pump), filtering (filter), routing (manifold) and maintaining constant flow rates to each injector (regulator). The regulator keeps the flow constant by increasing fuel pressure and manifold pressure is near ambient and dropping pressure as the manifold vacuum increases.

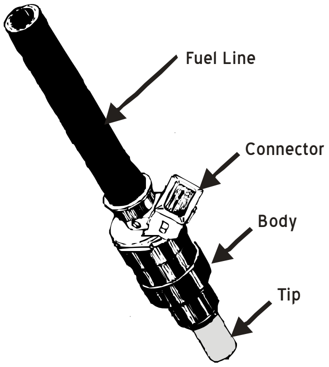
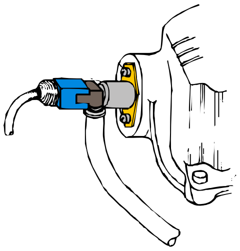
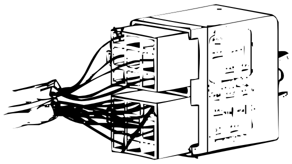
5.9 Component Reference

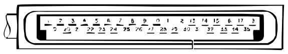
The following pages contain sketches and part numbers for the various fuel injection system components and brief descriptions of each.

Table 3: Major Fuel Injection System Components

Component	Description
	**Lambda Sensor** P/N 0 258 001 051 The lambda sensor meters the presence of oxygen in the exhaust gases and reports the level of oxygen to the ECU. It is located in the exhaust system before the catalytic convertor. Failure of this sensor will occur at approximately 30,000 miles or sooner on a poorly operating engine and will result in reduced efficiency. An engine that burns oil will ruin the sensor regularly.
	**Air Flow Meter** P/N 0 280 202 023 The air flow sensor is the point of entry for air into the fuel injection system. It measures the volume and temperature of air entering the engine and switches the fuel pump on when air is drawn into the engine.
Replace with good picture	**Coolant Sensor** P/N 0 280 130 023 The water temperature sensor is a hex-head brass component located in the cooling system pipes. On a 2000cc engine it is located in the coolant "T" in front of the head and between the cam drive wheels and the radiator.

Component	Description
	**Auxiliary Air Regulator** P/N 0 280 140 120 or 0 280 141 013 (Spider with A/C) This device allows air to be drawn directly into the plenum, bypassing the throttle plate. The effect is an increase in idle speed – the computer will give the engine more fuel to create an appropriate ratio to the inbound air. Once engine temperatures reach the normal operating range the auxiliary air valve closes.
	**Fuel Pressure Regulator** P/N 0 280 160 214 The fuel pressure regulator receives fuel from the fuel pump and keeps the fuel pressure into the injectors constant. It is located on the fuel rail and connects (via the rail) to the injectors and fuel pump. A smaller vacuum hose connects this regulator to the intake manifold. It maintains a constant flow rate at the injector tip as manifold pressure varies; increasing fuel pressure when manifold is near ambient and dropping it as the manifold vacuum increases. Failure of this device can cause fuel starvation or too much fuel in the system, affecting performance.
	**Fuel Pump** P/N 0 580 464 019 Located under the car and near the fuel tank, the fuel pump delivers fuel through the fuel filter and the fuel rail and into the injectors.

Component	Description
	**Fuel Injector & Seals** P/N 0 280 150 127 (DSO Spiders) or 0 280 150 121 (CSO Spiders) Seals P/N 1 280 206 702 and 703 A fuel injector is an extremely simple electrical device. The ECU will send a small current to the injector (via the connector), opening the injector and allowing fuel from the fuel rail to spray through the tip and into the engine. The tip of the injector is an insulator; the injector itself is a small opening in the center of the tip. Injectors are seated in the manifold with large rubber isolators around the tip and the injector body, insulating the injector from vibration.
	**Cold Start Injector** P/N 0 280 170 041 Upon receiving the "on" signal from the ECU, the cold start injector sprays fuel into the intake plenum, creating the rich fuel mixture required during cold starts. The duration of time in which the injector operates is determined by the thermo-time switch.
	**Double Relay** P/N 0 332 514 127 The double relay consists of two relays molded into a single container. It is located near the ECU. Signals from the ECU enter the relay and trigger higher voltage components.

Component	**Description**
	**ECU** P/N CU97X The ECU is a small computer located under the glove box. It is not a serviceable component. The connector on the ECU is used to test many of the sensors in the FI system.

5.10 Fuel Injection Tuning

A fuel injected Spider does not require (or allow) mixture adjustment. Tune-ups typically include the steps outlined above (in "All Engines"), setting the idle speed, and adjusting the throttle position switch. The oxygen sensor should also be replaced if it is old or questionable.

5.10.1 Replacing the Oxygen Sensor

How old is your oxygen sensor? Don't know? Replace it. Sensors are good for approximately 30,000 miles. However, if your engine is running very poorly then do not replace the unit until good performance has been restored. No matter what you've read or heard the oxygen sensor on your Spider is not going to cause the vehicle to run poorly. Most people are not aware when the O2 sensor fails because the changes in performance are typically minor. Certainly the engine runs better if all sensors are working properly, but the O2 sensor will not cause your car to go from running great to hardly running. If you're having performance issues that are major look elsewhere and leave your old O2 sensor installed so you don't ruin a new one (they damage very easily with overly rich or lean engines).

5.10.2 Idle Speed Setting.

Run the engine to normal operating temperature. On cars with automatic transmissions, set the parking brake, block the wheels, and put the transmission in "D". Completely seat the idle speed screw. Loosen the accelerator linkage stop screw retaining nut and adjust the stop screw to achieve 800 to 900 RPM on manual transmissions and 700 to 800 RPM on automatic transmissions.

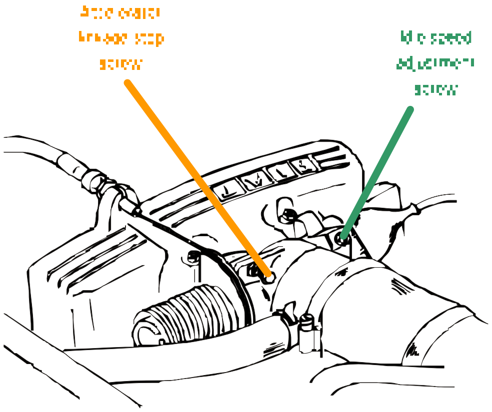


Figure 37: Idle speed controls on the Spider 2000

Lock the accelerator stop screw with the retaining nut. Use the idle speed screw (1) to set idle at 850 to 900 RPM on manual transmissions and 700 to 800 RPM on automatic transmissions. If idle speed cannot be reached using this procedure, fully remove the idle speed screw (2) and clean the orifice and the screw itself using a high pressure spray cleaner (carburetor cleaner is fine).

5.10.3 Throttle Position Sensor Adjustment

The throttle position sensor tells the ECU to turn off the injectors during deceleration. Improperly set it can affect the travel of the throttle plates and cause poor transition from full speed to cruise and idle operation.

Unplug the throttle plate switch. Note the connector blades (on the plate switch, not the connector itself) are marked "3" "18" and '2". Connect an ohmmeter between terminals 2 and 18 of the switch. Loosen the two screws holding the switch in place. Rotate the switch clockwise until the ohmmeter indicates a closed circuit. Tighten the two screws and reconnect the switch.

5.11 Fuel Injection System Electrical Diagrams

These diagrams are part of a complete set for the 1980 – 1982 Spider available at www.artigue.com/fiat.

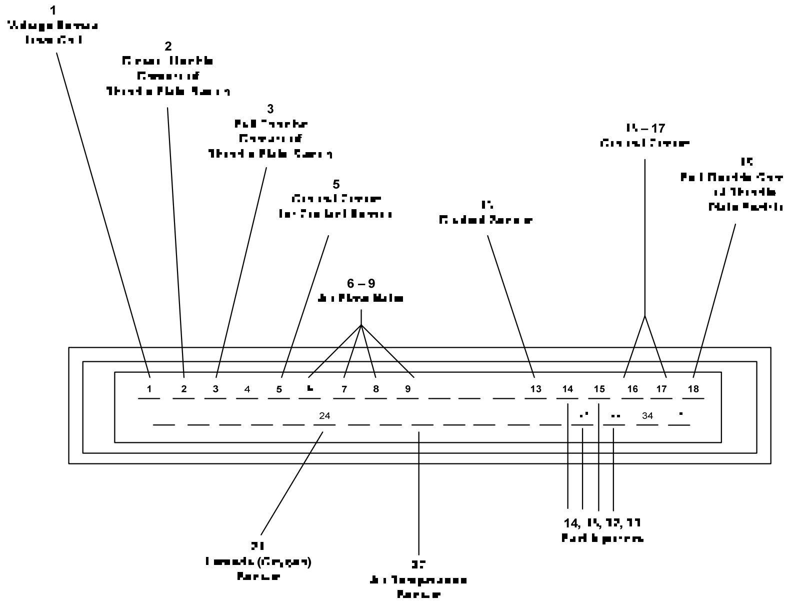


Figure 38: Primary Connections on the Electronic Control Unit

If you need a high quality print, download the diagrams from the website noted above and print from that file to virtually any size. Most copy and print shops have large scale plotters that can print on engineering size paper, such as 24 x 36 inches.

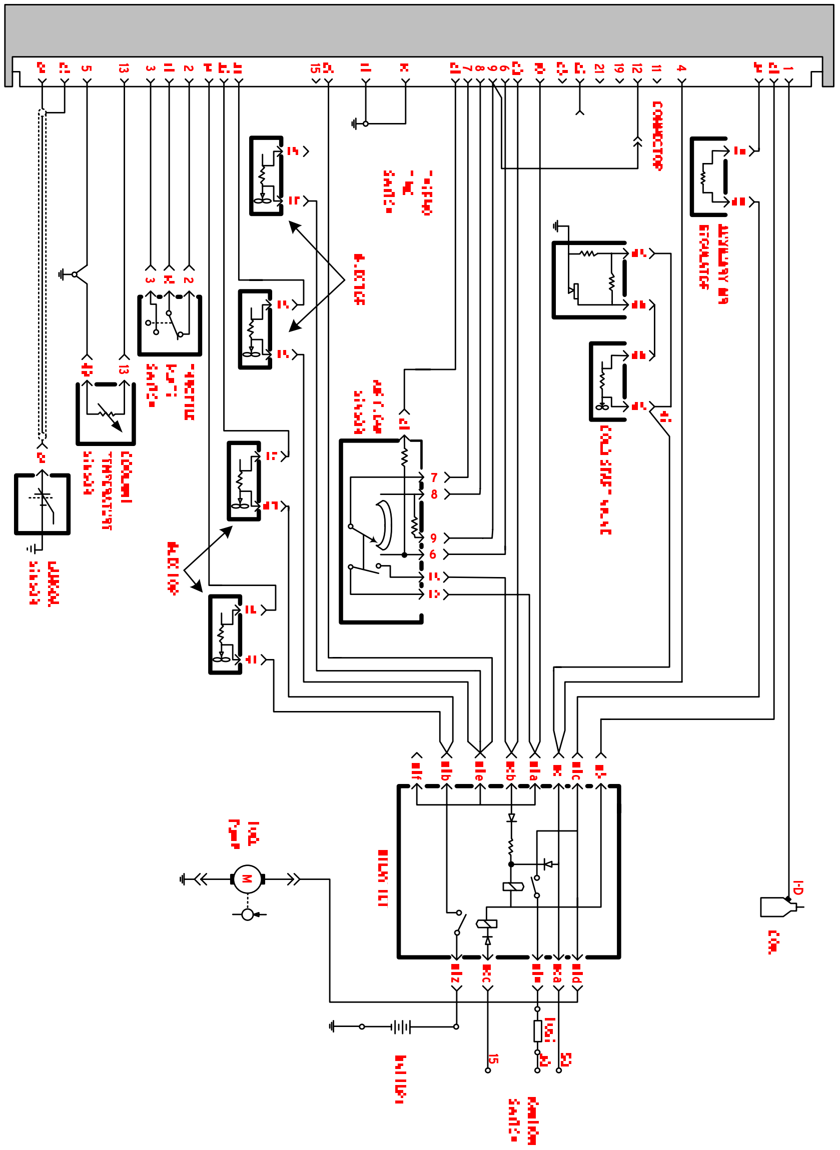


Figure 39: Primary Fuel Injection Circuits

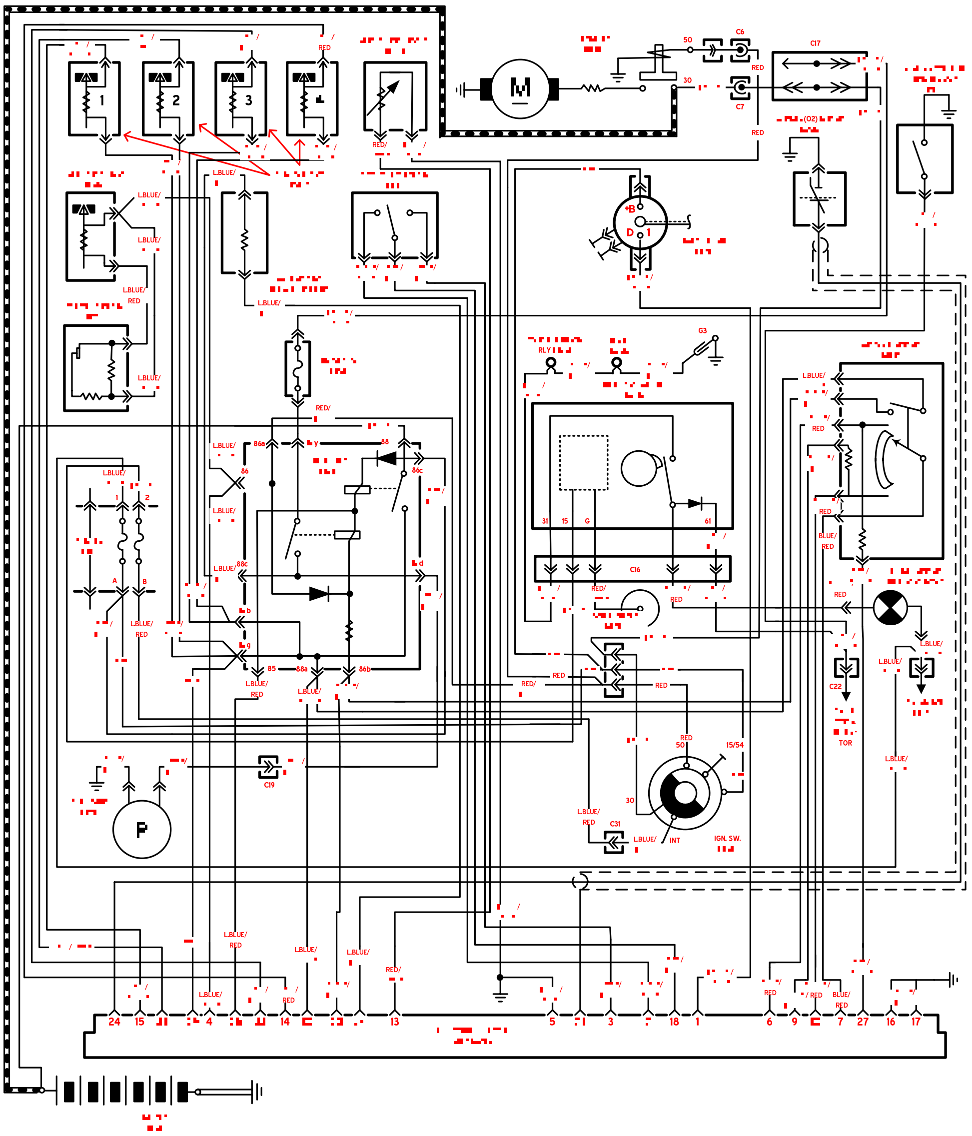


Figure 40: Fuel Injection System Electrical Diagram

5.12 Fuel Injection System Part Numbers

Table 4: Fuel Injection System Part Number Reference

	1983	**1982**	**1981**	**1980**
ECU	CU97X	CU97X	CU96X	CU96X
Injection Valve	0 280 150 127	0 280 150 127	0 280 150 121	0 280 150 121
Injection Valve Seal	1 280 206 702	1 280 206 702	1 280 206 702	1 280 206 702
Injection Valve Seal	1 280 206 703	1 280 206 703	1 280 206 703	1 280 206 703
Fuel Filter	0 450 905 030	0 450 905 030	0 450 905 030	0 450 905 030
Fuel Pump	0 580 464 019	0 580 464 019	0 580 464 019	0 580 464 019
Air Flow Meter	0 280 202 023	0 280 202 023	0 280 202 023	0 280 202 023
Auxiliary Air Valve	0 280 140 120	0 280 140 120	0 280 140 120	0 280 140 120
Cold Start Vale	0 280 170 041	0 280 170 041	0 280 170 041	0 280 170 041
Combi-Relay	0 332 514 127	0 332 514 127	0 332 514 121	0 332 514 121
Thermo-Time Switch	0 280 130 214	0 280 130 214	0 280 130 214	0 280 130 214
Oxygen Sensor w/Connector	0 258 001 051	0 258 001 051	0 258 001 051	0 258 001 051
Pressure Regulator	0 280 160 214	0 280 160 214	0 280 160 214	0 280 160 214
Temperature Sensor Coolant	0 280 130 023	0 280 130 023	0 280 130 023	0 280 130 023
Throttle Switch	0 280 120 300	0 280 120 300	0 280 120 300	0 280 120 300

5.13 Diagnostics and Troubleshooting

5.13.1 Air Input Diagnostics

Air leaks are the single most common cause of fuel injection system problems. Air entering the system from any part of the engine not connected to the fuel injection system is "false air" – it is entering the engine in an unknown quantity and state, and causing problems with the air/fuel ratio calculations.

If you are experiencing problems with the L-Jetronic system, start with air. Use a can of fuel injection or carburetor cleaner spray around the various hoses, clamps and around the injector seals. Spray around the plenum gaskets as well. While you are doing this the engine speed should not increase or decrease as a result of the spray. If it does you've likely found a leak.

5.13.2 Sensor Diagnostics

Coolant Temperature Sensor

The coolant sensor is tested on the ECU connector. Unplug the ECU and connect an ohmmeter between terminals 13 and ground (vehicle body). The meter should read:

Temperature (F)	OHMs
14	7,000 to 12,000
68	2,000 to 3,000
176	250 to 400

If the reading is 0 or less replace the sensor. If the reading is infinity check the wires leading to the sensor for a break. If the wires are good, replace the sensor.

The coolant temperature sensor can cause the engine to stop running. If your fuel injected Spider is running nicely and suddenly stops, inspect the wires leading to this sensor. Bosch makes a replacement wire and connector set that will eliminate this issue (for the next 20-30 years, then it will become brittle and fail again!)

Thermo-Time Switch

The engine must be completely cold to conduct this test. It is easier to perform this test when the ambient air temperature is less than 80 degrees. Disconnect connector from cold start valve. Install a test light or voltmeter to the connector. Start the engine and note that the thermo time switch should be on for 1 to 8 seconds while the engine is colder than 95 degrees F. Above 95 degrees the sensor will not trip.

Cold Start Injector

The engine must be completely cold to conduct this test. It is easier to perform this test when the ambient air temperature is less than 80 degrees F. Unbolt the cold start valve from the intake plenum and place the tip in a container. Operate the starter. The valve should spray for 1-8 seconds or while the engine coolant is under 95 degrees F. The valve should have a fine misting spray, not a drip. If the valve fails to shut off or never sprays replace the valve.

Air Flow Meter

The air flow sensor flap should move freely and return quickly to the closed position. The sensor must be clean. The air flow sensor is tested on the ECU connector. Unplug the ECU connector and connect an ohmmeter between terminal 6 and terminal 8. Resistance should be no more than 600 OHMS. Connect an ohmmeter between terminals 7 and 8. Resistance should be no more than 1200 OHMS. Connect an ohmmeter between terminals 8 and 9. Resistance should be no more than 350 OHMS.

Oxygen Sensor

Connect a voltmeter to the oxygen sensor and ground. The changes are constant - under hard acceleration and wide-open operation the sensor will read very high; under nominal operation it will cycle between 100mV and 1000mV.

Auxiliary Air Regulator

The auxiliary air regulator voltage can be tested by connecting a test light or volt meter to the connector poles. Voltage will be apparent when the engine is running. If voltage is not apparent replace the double relay. The air regulator may be suspect if the vehicle is idling poorly and all idle-related tests have been completed successfully.

Fuel Pump and Pressure Regulator

The fuel pump should never be noisy. Voltage at the pump terminals should be approximately 12V; terminals are prone to getting dirty and cleaning them may improve connectivity. Terminals should have rubber boots over them; if not consider covering connections with electrical tape or silicone. Fuel pump operation can be tested by testing the fuel line pressure in the engine compartment. Fuel feed pressure is 36 +/- 3 psi with the fuel pressure regulator disconnected. Pressure is 28 psi with the regulator connected.

Fuel Injectors

Injectors can be tested by removing the injector and placing the nozzle in a glass container. Operate the engine and check that the fuel spray is a mist. There should be no drips. Injectors pulse during normal operation (see below). You can test the injector voltage pulse with a voltmeter or test light. Disconnect an injector plug and connect to each plug in the connector. Operate the starter (the car may or may not start) and note that voltage should pulse - making the light flicker weakly or the voltage to fluctuate. If there is no fluctuation then the ECU may be bad.

5.13.3 Troubleshooting

The Bosch L-Jetronic system is extremely reliable; however, it has been over 20 years since the last L-Jetronic was installed in a FIAT Spider. Electronic parts fail over time, and those exposed to the heat and filth of an engine bay are no exception. If you are working with a newly acquired Spider or have never diagnosed all of your sensors it may be worthwhile to go back to the "Sensor Diagnostics" section and test your fuel injection system if you have not done so already.

Table 5: Fuel Injection System Troubleshooting

Symptom	Engine cranks but does not start	Engine starts but then dies	Rough or unstable idle	Idle speed incorrect	CO value incorrect	Erratic Running	Engine misses when running	Fuel consumption too high	No maximum power	**Cause**	**Remedy**
1	•	•	•	•		•	•	•	•	Defect in ignition system	Check battery, distributor, plugs, coil, and timing
2	•	•	•	•		•	•	•	•	Mechanical defect in engine	Check compression, valve adjustment, and oil pressure
3	•	•	•	•	•	•	•		•	Leaks in air intake system (false air)	Check all hoses and connections, eliminate leaks
4	•	•	•					•		Blockage in fuel system	Check fuel tank, filter, and lines for free flow
5	•									Relay defective; wire to injector open	Test relay, check wiring harness
6	•									Fuel pump not operating	Check pump fuse, pump relay, and pump
7	•	•	•		•	•		•		Fuel system pressure incorrect	Check pressure regulator
8	•									Cold start valve not operating	Test for spray, check wiring and thermo-time switch
9	•	•	•	•	•	•		•		Cold start valve leaking	Check valve for leakage
10	•									Thermo-time switch defective	Test for resistance readings vs. temperature
11	•	•	•	•						Auxiliary air valve not operating correctly	Must be open with cold engine, closed with warm
12	•	•	•		•			•		Temperature sensor defective	Test for 2-3 kiloOHMS at 68 degrees F
13	•	•	•	•	•	•		•	•	Air flow meter defective	Check pump contacts; test flap for free movement
14			•	•					•	Throttle butterfly does not completely close or open	Readjust throttle stops
15			•						•	Throttle valve switch defective	Check with ohmmeter and adjust
16		•	•	•	•					Idle speed incorrectly adjusted	Adjust idle speed with bypass screw
17			•		•	•	•		•	Defective ignition valve	Check valves individually for spray
18		•	•	•	•	•	•		•	CO concentration incorrectly set	Readjust CO with screw on air flow meter
19	•	•	•			•	•			Loose connection in wiring harness or system ground	Check and clean all connections
20	•	•	•				•		•	Control unit defective	User known good unit to confirm defect

The Bosch L-Jetronic troubleshooting table is presented in the table above. It does a good job of presenting many of the common faults with the system and giving possible causes and remedies. This is followed by troubleshooting problems that are specific to the FIAT Spider.

Air Flow Meter Failures

According to Bosch, any malfunction of the AFM should result in replacement. At about $500 each, this isn't always the best option. Some issues are easy to diagnose and repair yourself.

A sticking intake valve can cause air from engine compression to push backwards through the fuel injection system. The net result is often a bent AFM flap and very poor or no running. Some Spider AFMs have an accommodation for this, a circular spring-loaded "door" in the middle of the air flow meter flap that opens with pressure. This door often blows apart, sparing the flap. A bent flap may be repairable by bending it back into place or, if the door bent slightly down, by sanding (with very fine sandpaper) the aluminum surfaces inside the AFM door. A blown circular door can be fixed with epoxy (it will no longer open, meaning you need to fix the sticking valve or problem that caused it to blow out).

Keep in mind that if you are stuck on the side of the road due to an AFM door failure, the circular type should leave the AFM flap workable but with a quarter-sized hole in the middle. It can be temporarily covered with duct tape as an emergency fix. Attach to the outside only, you don't want duct tape sucked into your engine! This procedure works quite well, as your author learned it the hard way.

Also note, an engine that is bending AFM flaps is going to bend the flap of any AFM you put on the engine; the problem is in the valve train and should be repaired there before wasting money on air flow meters.

Temperature Sensor Failure

The temperature sensor is unlike the other sensors in the fuel injection system in that, when it fails, the car typically will not run. Many times this problem is diagnosed as the sensor and a replacement occurs. This sensor is in a very hot part of the engine, exposing the sensor and wiring to harsh conditions. It is important to inspect the wiring leading to this sensor and make sure it is in very good condition. A replacement connector and wiring is available to splice it if there is any question.

Click-Click-Clicking Double Relay and Fuel Pump Eccentricity

Assume you are driving along and, while at or near idle, you hear a very rapid click-click-click-click (etc!) coming from the passenger side of the car. The double-relay is likely turning on and off very quickly. This is the result of the fuel pump switch in the air flow meter being set too low, so that the pulse of air during idle keeps turning the pump on and off. Adjust the rod as described in the "Air Flow Meter Failure" section above.

The fuel pump may begin behaving erratically or running "all the time" (draining the battery). The pump is activated by a chrome rod inside the air flow meter. When the AFM flap moves the pump turns on. Therefore when your engine is cranking, idling, or cruising, the pump is on. Over time the rod may move out of position; it can be fixed by lifting the black cover off of the AFM and bending the rod so that the pump is on only when the flap has moved.

6. The Cylinder Head

If you open your hood and look at the center of the engine you'll see four spark plugs. The aluminum thing that your spark plugs are screwed into is the cylinder head. The cylinder head on a FIAT 124 Spider is of the semi-hemispherical, dual overhead cam (DOHC) type. It is called semi-hemispherical because the operation occurs along a 180 degree arc. The two camshafts sit on either side of the spark plugs and rotate in time with the engine main crankshaft to draw in, burn, and expel fuel. A cylinder head has three major components:

> **Camshafts** are metal poles with lobes on them. The lobes press against valves that open and close, allowing gases into and out of the engine. Lobes are engineered into a specific pattern, resulting in the camshaft being the mechanical brain governing the Otto cycle.
>
> **Valves** cover ports between the intake and exhaust manifolds and the combustion chamber. Valves are held closed by a high tension double-spring assembly. The spring is held down by retainers installed in a donut-shaped cap. The entire assembly is capped off by a bucket. The camshaft strikes a shim on the top of the bucket, opening the valve. The shim is adjustable to maintain proper valve clearance.
>
> **Spark plugs** descend into the combustion chamber and create a spark that ignites the air/fuel mixture.

We start this section with the intake of fuel from the fuel system and finish with the expulsion of spent fuel into the exhaust system. Assume your engine is just starting the intake cycle – the camshaft has depressed the intake valve, drawing air and fuel into the combustion chamber (figure 41.1). As the camshaft rotates the valve closes. The piston is pushed upwards, compressing the mixture (figure 41.2). Ignition occurs (figure 41.3), exploding the mixture and forcing the piston down. Finally, the camshaft opens the exhaust valve and the piston is drawn up, expelling the burned mixture (figure 41.4).

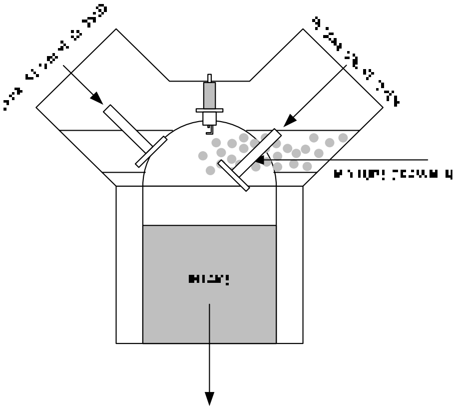


Figure 41.1: Intake

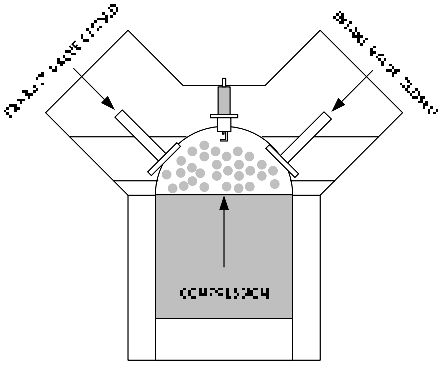


Figure 41.2: Compression

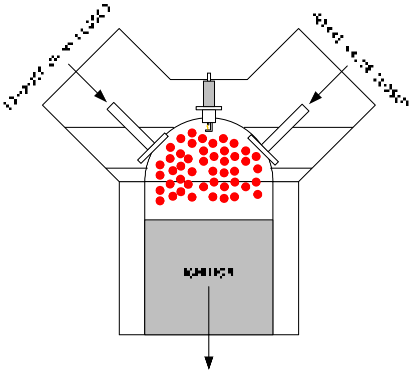


Figure 41.3: Ignition

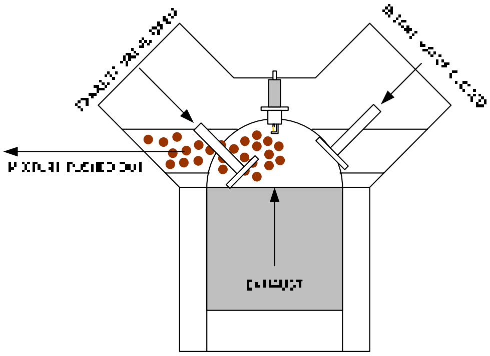


Figure 41.4: Exhaust

The diagrams above show the absolute end or beginning of each cycle. The duration of time that the valves remain open and the timing of when each valve opens are determined by the shape of lobes on the camshaft. On the FIAT DOHC there are two camshafts, each with four lobes (one per valve, two banks (intake and exhaust)). The camshaft lobes move through the four phases for each 90 degrees of rotation. In a DOHC engine the opposite camshaft is in the same position and having the opposite action; in other words, when the intake camshaft is in the intake position the exhaust camshaft would be at the same angle, performing no action on the exhaust valve.

6.1 Cylinder Head Identification

Cast into the top of your cylinder head is an embossed identification number. Because it is possible (and oftentimes desirable) to install an earlier cylinder head on some blocks, you need to identify if such a swap has occurred on your engine.

Table 6: Cylinder Head Casting Number Table

Casting Number	Other Casting ID	Displacement	Comments
4166393	124AC	1438	1968 124 Spider
4198994	124AC	1438	1969 124 Spider
4232871	124AC.000	1608	Sport Spider
4232974	124AC.000	1608	1972 124 Coupe
4238527	132AB.1A.0	1592	Sport Spider
4239436	124AC.000	1608	124 Coupe
4239436	124AC.000	1608	124 Coupe
4268803	124AC.000	1608	1972-73 Sport Spider
4277590	132AB.9A	1756	1974-76 Coupe
4304781	132AC.OC	1592	1973-1974 Spider
4314402		1756	Late 124 Spider
4325215		1995	131
4326319	124AC	1608	Early 124
4348553	134AC.6C	1756	Lancia Scorpion
4371507	132.C8.1A0	1592, 1756, 1995	131/132 and 1981-82 Spider
4372281		1995	1980 Lancia Beta
4372291	134AS	1756, 1995	1977 Spider
4372297		1592, 1995	131
4372748		1995	131
4406111	132AC.2C	1995	1979 131 & Beta Coupe
4439644	132AC.2C	1995	79 Brava
5992129		1995	1984 Spider

http://www.mirafiori.com/faq/content/headid/headid.html

Pete Angel maintains the table above and has made these additional comments on head identification:

- The 1438 twin cam head is lacking an additional water passage on the intake face, rear of the #4 intake port. All other heads have a water passage there. This makes other intake manifolds incompatible on the 1438 unless the water passage in the manifold is blocked. Conversely, the 1438 manifold cannot be used on the other heads unless the passage in the head is blocked.

- The center-to-center combustion chamber spacing is the same on all heads. The combustion chamber sizes vary with the USA 2000cc amongst the largest, affording the lowest compression ratio.

- The 1438 and 1608 heads can be distinguished from other twin cam by the size of the water passage on the head face in front of cylinder #1. The width of this passage on these heads is 14mm (0.55"). The 1592cc, 1756cc & 2000cc heads have a 9mm (0.35") wide passage. Because of this, the 1438cc & 1608cc heads will not work on the 84 mm bore engines unless this water passage is welded.

- The exhaust port size is nearly identical on all DOHC heads. The intake port size varies. Generally, the smallest port size is found on the 1438cc. The 1608cc, 1756cc & Volumex heads share approx the same, large intake port size.

7. Intake Manifolds

FIAT used two types of intake manifolds on carbureted engines. The type of manifold was relative to the type of carburetor. Carburetors fitted with a vacuum operated secondary barrel (those with an "H" in the name) were fitted with a manifold with different sets of upper and lower runners. These can be identified by removing the carburetor and noting that the two barrels have their own plenums, instead of one large opening underneath the carburetor base. When using the vacuum type carburetors it is important to have the dual planes for proper opening of the secondary barrel; when using the non-vacuum carburetors the split planes will impede performance. Therefore it is important to have the correct manifold for your carburetor and, if you are planning a swap to another carburetor, that you are also planning for a manifold swap.

Table 7: Intake Manifold Casting Numbers

Part Number	Original Fitment
4186411	1438cc 1967-1968
4226586	1438cc 1968-1970
4242994	1608cc 1971-1973 (Dual IDF)
4248067 / 4248068	1608cc 1971-1973
4304461	1592cc 1973
4308888	1756cc 1974
4334447	1756cc 1975-1978
4406112	2000cc 1979-1980 (Carbureted)
4468499	2000cc Fuel Injected

8. Exhaust System

The exhaust system conveys spent gasses from the cylinder head to the exterior of the car. Exhausts perform a number of valuable functions and exhaust design is crucial to good engine performance. Emissions, noise, and backpressure are key concerns in exhaust design. Emissions must be safely conveyed away from the passenger compartment; in the case of the FIAT Spider they are reduced by a catalyst and expelled behind the vehicle. Noise produced by an engine must be muffled in order for the vehicle to function in society; therefore a muffler is installed at the rear of the vehicle to reduce exhaust noise. Spiders also have a center resonator, an additional muffling device located above the rear axle. Backpressure exists if gasses escaping the engine meet resistance and, taking into account the safety and environmental features noted above, is the focus of good exhaust system design.

A poorly-designed exhaust manifold may create pressures that inhibit the engine's ability to breathe. Many vehicles have intricate exhaust systems, designed specifically to equalize the length of each cylinder's exhaust pipe. FIAT Spiders used two types, known as 4-2-1 and 4-1; the former is considered to be a superior design. Aftermarket headers are also produced, each touting improvements to the original designs (with dubious pedigree; refer to the section titled "improvements" later in this book.)

There are two types of the 4-2-1 design. The first was fitted to 1756cc Spiders manufactured in 1974. There are four pipes running from the exhaust side of the engine, tapering down to where a flanged two-pipe fitting mates and extends under the car. Here a single pipe leads through a catalytic converter (or not, depending on year), through mufflers and out of the car. The second type of 4-2-1 was installed on the fuel injected Spiders. It is similar in design except the four primary pipes bend into two and into a collection "box" where the oxygen sensor is installed. The 4-2-1 was designed for Spider engines in the 100+ HP range and is at least as good (arguably better) as most "performance" aftermarket systems.

The 4-1 design was installed on most Spiders and in every engine displacement. Four short pipes extend from the exhaust manifold into a single pipe that runs under the car to the catalyst and onwards. The design is simple and the exhausts are very well built. They suffer only from the rather abrupt turns from the exhaust ports to the down pipe and, unless the engine is going to produce more power than stock, may not be worth replacing.

8.1 Exhaust System Identification

Look in your engine compartment at the exhaust side of the engine. There may be a metal heat shield on top of the exhaust - it will have three 13mm nuts securing it down. The exhaust system parts have the part numbers stamped into them. It is very unlikely that a Spider will have the original parts from the down pipe back.

Table 8: Exhaust System Casting Numbers

Year	Manifold	Header Pipe	Intermediate Muffler	Rear Muffler	Note
1967	4151276	4310530	4401843	4285627	
1968	4151276	4310530	4401843	4285627	
1969	4151276	4310530	4401843	4285627	
1970	4151276	4310530	4401843	4285627	
1971	4151276	4310530	4401843	4285627	1438cc
1971	4166429	4310530	4401843	4285627	1608cc
1972	4166429	4310530	4401843	4285627	1592cc
1973	4166429	4310530	4401843	4285627	
1974	4308891	4310530	4401843	4285627	
1975	4314919	4341428	4341867	4285627	California
1976	4314919	4341428	4341867	4285627	
1977	4380776	4341428	4341867	4285627	
1978	4377811	4341428	4341867	4285627	
1979	4407872	4419699	4419683	5976218	
1980	4407872	4419699	4419683	5976218	
1980	4462282	4443328	4443325	5976128	California
1981-1985	4462282	4443328	4443325	5976128	To Chassis 5506060
1981-1985	4462282	7531187	4443325	5976128	From Chassis 5506061

9. Ignition

The ignition system in your FIAT is one of four types, all of which operate according to similar principles. For the vast majority of Spiders, a distributor is mounted on the rear of the cylinder head. Some early Spiders were fitted with distributors that run off of the oil pump gearing. In both cases a shaft inside the distributor body spins in time with the engine camshafts. The drive shaft turns a metal-tipped rotor that strikes connectors inside of the distributor cap. When contact is made an electrical connection between the spark plug and the distributor coil is made, sending a current from a high energy coil and generating a spark that ignites the fuel mixture in the combustion chamber. As the distributor rotates through its cycle the electrical pulse is sent to the tachometer, resulting in a reading of engine speed in revolutions per minute (RPM).

The 1967-1972 Spider had a simple "single point" distributor, where a single set of points was activated by the movement of the distributor shaft. From 1973 (on the 1592cc engine) through 1978 FIAT used a "dual point" distributor, where one set of points was used for starting and another for running. The first set (the starting set) created additional advance during starting. After 1978 an electronic system was used. The points used in prior models were replaced with devices that electronically controlled the spark and vacuum controlled the advance. A fourth system was made available by FIAT for a brief period of time, and is coveted by many Spider owners. The Marelliplex is a mechanically-advanced electronic distributor. To a Spider owner it eliminated the dependence on the throttle-controlled vacuum pulse of the stock electronic unit, yet used all stock components otherwise. All four systems are extremely reliable when properly maintained.

9.1 Ignition Components

For our purposes, the major components of the ignition system are the coil, distributor, spark plugs, and wires. Depending on the type of system (electronic or mechanical) there are other pieces and parts, such as points, condensers, magnetic pickups, and control modules. We'll cover the important pieces that you need to understand in getting to know your Spider.

The Coil stores electrical energy. It is a cylinder bolted to the firewall and is easy to spot as it has one big wire coming from the top and smaller wires from either side. On Spiders made from 1979 to the end of production the coil was part of a pack that included a finned housing and control module.

The Distributor is an electrical switch, using engine rotation to propel a rotor against a series of contacts. As the distributor shaft turns an electrode on the rotor makes the connection between the coil and each of the spark plug wires. A set of points (1967-1978) or a magnetic pickup (1979-1985) releases energy from the coil into the wires.

Spark Plugs have electrodes suspended in the combustion chamber and are connected to a cap on top of the distributor by wires. When the distributor releases the coil's energy it travels through the cap, into plug wires, and into the spark plugs. The resulting spark ignites the fuel/air mixture in the combustion chamber.

Plug Wires are designed to contain the high energy of the coil and deliver it to the spark plugs. They are the largest wires in the engine compartment and are quite obvious as they run the top of the cylinder head.

Points are small electrical switches that open and close as the distributor rotates. When the points are closed an electrical field builds up in the ignition coil. When they open the field collapses, releasing energy into the spark plug.

A Condenser is a small (typically silver) barrel on the body of the distributor. It absorbs misdirected (for lack of a better term) energy that runs from the coil back to the points instead of to the spark plugs. Without a condenser the points will deteriorate quickly or weld themselves together.

The Magnetic Pickup is the equivalent of points on the electronic ignitions installed in the 1979-1985 Spider. Instead of the striking motion and inevitable wear associated with points, a magnetic pickup literally "picks up" the increasing and decreasing magnetic wave created by lobes in the distributor shaft. The energy from the coil is released by a control module located on the coil itself.

The Control Module is located on the coil pack of the 1979-1985 Spider. It electronically collapses the coil's electrical field.

The Vacuum Module is a dashpot located on the side of the 1979-1985 Spider distributor. A diaphragm inside the dashpot is connected to a shaft that pulls or pushes the advance plate. The diaphragm is moved via vacuum pulse from the throttle body. On fuel injected cars it is connected to a port located near the throttle on the air flow meter side of the throttle plate. On carbureted Spiders the port is located just above the throttle plates. In both cases when the throttle opens a drop in air pressure pulls on the diaphragm which in turn moves the advance mechanism.

9.2 Ignition System Identification

All Spiders made prior to 1979 had breaker points. A single-point distributor will have a coil mounted to one of the inner fenders and a single condenser on the distributor body. It is the least complex of the Spider ignition systems. A dual-points distributor is similar to the single-point but has two condensers on the body and two sets of points on the interior. Some 1973-1978 Spiders have had the dual-points removed (replaced with a single point internally) or the entire distributor replaced with the single-point model. The single and dual point distributors can be identified externally; single-point distributors have a single condenser and wire (blue/black) running off of the distributor. Dual-point distributors have two wires (green and green/black). The coil for both units is a common barrel type mounted to the inside of the driver's side fender on the early models and the passenger side on the late models.

The electronic ignition system of the 1979-1985 Spiders can be identified by the large coil pack mounted on the passenger side fender wall. If stock it will have an enclosure of aluminum fins to each side and a control module on the bottom back. Most electronic distributors will be stock, with a vacuum canister mounted on the side. Two wires wrapped in a small diameter tube run from the distributor pickup to the coil pack. The now rare FIAT replacement part known as the Marelliplex system looks identical except that it has no vacuum canister on the side of the distributor (and no way to install one; a sure way to identify a fake Marelliplex is to see if the base has the opening and fitting for the vacuum dashpot).

Table 9: Ignition System Components

Series	**Seal**	**Cap**	**Rotor**	**Condenser**	**Breaker Points or Pickup Unit**	**Coil Unit**
AS	9915908	9925467	9924654	9913848	9913862	▨
BS1	9921512	9925467	9924394	9922454	7111161	▨
CS1	9921512	9925467	9924394	9926424 (74-77) 9929180 (73)	7111161	▨
CS2	9921512	46340	56290	859818	9937730	4386220
CS0	9921512	46340	56290	859818	9937730	4386220
DS0	9921512	46340	56290	859818	9937730	4386220

9.3 Ignition Advance

In your Spider the basic ignition timing is set to either 5 degrees (1438cc), 0 degrees (1592cc, 1608cc 1756cc) or 10 degrees (1978 1756cc and all 2000cc) behind top dead center (BTDC). This means that the spark plugs "fire" when the crankshaft angle is almost at the absolute top of travel. This is called ignition *advance*. Advance is a term applied to timing an engine in such a way that the spark is delivered just before the piston reaches top dead center. This is necessary because there is a time lag between when the spark is delivered and the fuel/air mixture and cylinder pressures are optimal. If the spark occurs at top dead center then the piston is already moving down when these optimal conditions are possible. Therefore the spark is forced to occur just prior to top dead center; the fuel/air ignition begins and reaches its maximum at the appropriate time.

A variation in ignition advance is required to maintain optimal efficiency. Beyond the "hard" setting of 0 or 10 degrees BTDC the ignition distributor has a metal plate that moves according to engine speed. This movement, governed by either centrifugal or a combination of centrifugal and pneumatic force, varies the advance so that the spark is delivered at the optimal point, up to 32 degrees BTDC (depending on series, some were limited to 28 degrees).

Spiders manufactured prior to 1978 have centrifugal advance plates, the movement of which is driven by the spinning of the distributor shaft. As the shaft increases in speed the centrifugal force moves the advance plates outward, increasing the advance.

On Spiders manufactured after 1978 (the CS2, CS0, and all Pininfarina Spiders) the vehicles were fitted with a Marelli electronic ignition with a pneumatically-operated advance mechanism. It has often been misidentified as a pollution control – it certainly is not. The diaphragm in the distributor varies the amount of advance when it is pulled by the drop in air pressure that occurs when the throttle opens. As the throttle opens and more air enters the engine the amount of advance increases. This design makes the ignition advance dependent on the actual load of the engine rather than the speed of the engine; arguably a more efficient design.

9.4 Firing Order and Initial Timing

All FIAT Spiders fire in the order 1-3-4-2. The initial timing is set so that the camshafts and crankshaft are in the initial position, with camshafts aligned with pointer holes and crankshaft aligned to the block mounted pointer. When this initial position is met the engine is set to fire on the #4 cylinder (figure 43).

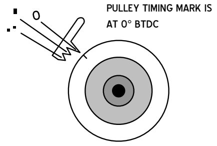
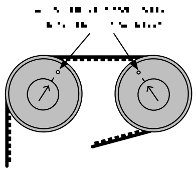
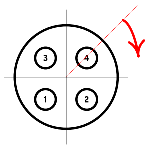
Crankshaft	Camshaft	Distributor Rotor Position
		

Figure 42: Initial Ignition Setting

A nut holds the distributor shaft down on the engine block or cam box. To turn the distributor (the engine does not need to be turned on at this point), simply loosen the nut so that the distributor rotates. It is useful to loosen it only enough so that it will turn, some tension is desirable and holds the unit in place while you turn the distributor.

Once the initial settings are correct you'll need to set the ignition timing to the running position. This varies between engine types as described in the table below:

Table 10: Ignition Advance by Engine Type

Motor	Degrees of Advance BTDC
1438cc, 1608cc	5
1592cc	0
1796cc	0
2000cc	10

If you removed the distributor cap and wires in the previous setting you'll need to re-install them now. You should keep the distributor loose enough to rotate since you'll need to rotate it again.

Start the engine and let it run until it reaches 190 degrees F (usually two complete cycles of the fan). If the engine will not run rotate the distributor slightly in either direction until it will run, or increase the idle speed screw to hold the throttle open. Once 190 degrees is reached reduce the idle speed to approximately 850 RPM or 900 RPM for engines with air conditioning.

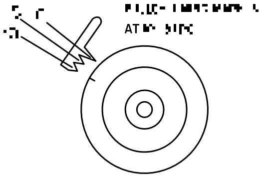
Timing Light	Engine Speed
	850 +/- 50 (w/o AC) 900 +/- 50 (with AC)

Figure 43: Final Timing (2000cc engine)

There are two methods you can use to set the initial ignition timing. One is "by the book," meaning you set it just like FIAT tells you to and lock it down. The second is to set the ignition timing by ear. There are advantages to both methods – your goal needs to be to set your engine to the point where it runs best, which may be "by the book" and may be "by ear."

The "by the book" method is to take the ignition advance information from the black metal plate inside your hood (if it isn't there then use the information in table 10 above). FIAT varied the timing data (to meet emissions regulations) enough that you want to rely on your car's data plaque if you can. Using a timing light on the #1 plug wire, start the engine and point the light at the crankshaft position marker. Rotate the distributor so that the timing is set per the crankshaft marker (see Figure 43). The engine speed may increase or decrease while setting the timing; adjust the carburetor idle speed screw accordingly to maintain the correct engine speed.

The "by the ear" method disposes of the need for a timing light. Once your engine is set to zero degrees BTDC you will advance the distributor to the point at which the engine speed is no longer increasing. Advancing the distributor improves combustion, resulting in increased engine speed, but at some point it is too much and a reduction occurs. Once the reduction begins retard the ignition until the engine speed is at the highest point without missing or puffing. Set the idle speed to the appropriate RPM.

In both cases you want to drive the vehicle and check what you've done. If you've tuned by the book you need to check the timing again with a light. If you've tuned by ear then make sure engine operation through acceleration and deceleration is nice and smooth. The ignition may be advanced too much (remember, the distributor further advances once it gets moving) and require you to retard it a few more degrees to get it all correct.

There is a third method – where you tune to the desired maximum advance. Richard Ridge submitted the following on my queries about ignition timing:

> **[What is optimum timing?] It is the timing that allows the car to start readily and smoothly accelerate while also delivering the highest peak torque possible under full load. And of course it also has to meet whatever emissions limits are required. It is not a single number, rather it is a curve, a smooth timing advance progression from a few hundred rpm to the rpm at peak torque.**
>
> **The actual numbers depend on cam timing, compression, head work, induction and exhaust configuration. Accuracy requires dyno work or trial and error on the street. Looking at the factory curves for different engine configurations is a good way to start.**
>
> **For a race engine that has no real starting, drivability or emissions restrictions, the answer does boil down to a single number. Others have suggested that for TC engines in typical competition trim, the number is in the 35-38 degree BTDC range.**

Given this information, if you want to seek out a specific degree of maximum advance you need to determine the maximum advance of your distributor, do a little math, and figure out your initial timing. If you want 35 degrees of advance and have a distributor with 30 degrees of total advance, your initial timing will be 5 degrees. Sounds simple, right? Trial, error, and patience will pay off if this kind of accuracy interests you.

The block mounted distributor on Spiders made prior to 1971 has approximately 5 degrees of fixed advance with a maximum of 29 degrees of variable advance. The advance increases in a linear manner to its maximum at 3500 RPM.

The camshaft mounted distributor on the 1971-72 Spider has approximately 5 degrees of fixed advance with an additional 24 degrees of variable advance. The variable advance increases in a linear manner from approximately 0 degrees at 850 RPM to 31 degrees at 4300 RPM.

The 1974 – 1978 distributor has approximately 10 degrees of fixed advance with the first (starting) set of points and 0 with the second (running) set (at 850 RPM). Normal running occurs on the first of points, with centrifugal advance to a maximum 36 degrees at 3500 RPM. The running points are activated when full oil pressure is reached and the water in the intake manifold passages begins to increase.

Dave Voss, a FIAT owner who took the time to disassemble and understand the differences in the 1979-1985 vacuum advance (electronic) distributors, noted the following:

> Given the age of these distributors, and the high likelihood that swaps and rebuilds have occurred along the way, your [electronic] distributor could be any one of 6 combinations:
>
> 47° total = 33° mechanical + 14° vacuum
> 43° total = 33° mechanical + 10° vacuum
> 33° total = 33° mechanical + 0° vacuum (failed or disconnected)
> 36° total = 22° mechanical + 14° vacuum
> 32° total = 22° mechanical + 10° vacuum
> 22° total = 22° mechanical + 0° vacuum (failed or disconnected)
>
> The distributor top plate, under the rotor, is stamped with the degrees of mechanical advance. The vacuum canister is also marked. Generally speaking the replacement parts available today are for the 49-state version and, unless pinging or knocking occurs during operation, the 49-state is appropriate for all Spiders. The electronic system also fits earlier models and is often found under the hood of many older Spiders.

To recap, ignition advance is a crucial concept in tuning. A recommended approach is to set your engine "by the book" and, as you understand more about your vehicle and your driving needs, begin to adjust "by the ear" or to the maximum advance. FIAT distributors interchange easily between vehicles, so the advantages of an electronic system on an older motor may be appealing, or using a single-point distributor on a mid-year Spider.

9.5 Ignition Electrical Diagrams

Note: These diagrams are excerpts from the electrical system diagrams I have produced for each FIAT Spider model year. The diagrams are available online at http://www.artigue.com/fiat.

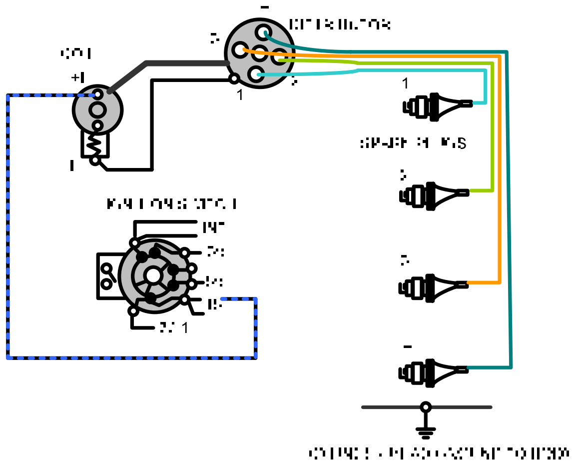


Figure 44: Ignition Electrical Diagram for the 1967-1973 Spider

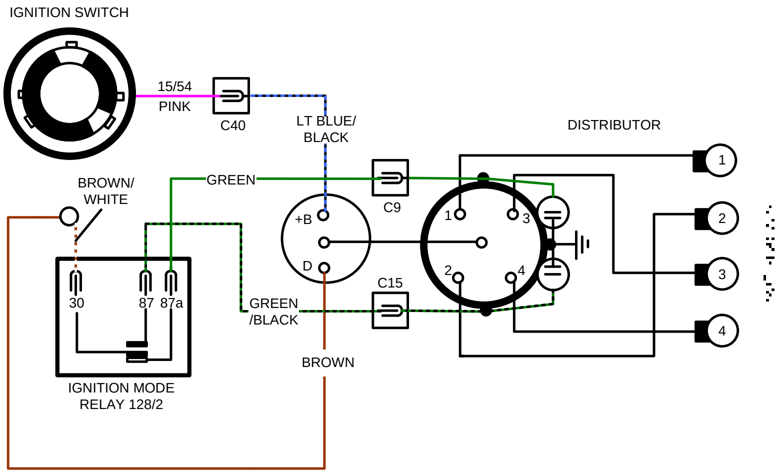


Figure 45: Ignition Electrical Diagram for the 1974-1978 Spider

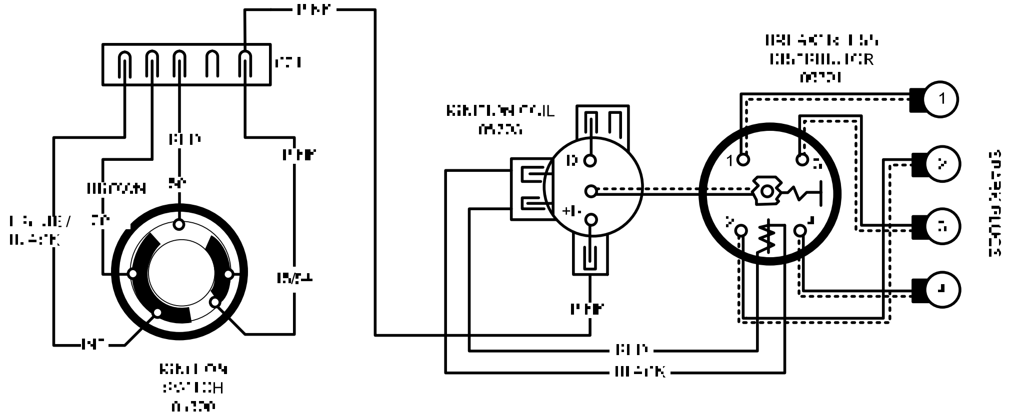


Figure 46: Ignition Electrical Diagram for the 1979-1985 Spider

9.6 Diagnostics and Troubleshooting

9.6.1 Electronic Ignition Failures

Vacuum Capsule

The failure of this capsule causes poor acceleration. With the engine running you should see the shaft between the dashpot (the barrel on the distributor body) and the distributor pulse. If someone presses the accelerator pedal you will see the shaft pull the shaft back towards the hose. If not then consider that air pulled through the hose (away from the dashpot) will move the shaft if the unit is operating properly. This is not to suggest you suck on the air hose – if you do and the diaphragm is broken then you will suck in the paper and other dirt from the busted diaphragm.

Note that some FIAT owners suggest that their car works fine with this unit disconnected or inoperable and the distributor manually advanced; you cannot set up your vehicle properly with this unit inoperable. It is far more likely that these owners have forgotten what the car is like with the advance mechanism working properly!

Ignition Pickup

The pickup wires can become hard and brittle over time. Wires may also ground on the distributor body. Both situations typically cause poor running and the tachometer may be erratic during operation. Inspect the wires at every oil change and change if they are suspect.

Rotor or Cap Failure

Old, brittle, or over-tight rotors can explode inside the distributor cap. They can spin themselves to pieces. The contacts inside distributor caps can also become brittle over time, as can the cap itself. Inspect and change them when necessary.

9.6.2 Conventional Ignition Failures

Points and Condensers

Poor operation, acceleration, and other running problems may be due to worn points. Inspect the points for the appropriate gap and dwell. Check that the points show even and not excessive wear. When replacing, change the condenser(s) at the same time.

9.6.3 Common Ignition Failures

Spark Plugs and Wires

Bad plugs and wires can arc, causing misfires and poor overall operation. Plug wires should not be brittle or have any corrosion on the contacts. At night with the hood open you should see no arcs between the wires and the engine body. There is no substitute for high quality 7mm or 8mm wires like Magnecor or Bosch. The spark plugs should be of the resistor type and free of corrosion. When removed from the engine they should be very clean and with a brownish-white “burn” on the electrode.

Coil

Missing or poor combustion can be caused by a malfunctioning coil. The coil and electronic coil pack are extremely durable and reliable units. The shop manual has procedures for testing each unit. When replacing do not use any coil unit on the electronic system not specifically designed for this purpose.

Poor Operation and Erratic Tachometer Display

Poor operation accompanied by a tachometer that is jumpy or otherwise erratic is often caused by a short circuit inside the distributor body. On both electronic and conventional distributors this may be caused by a broken rotor or metal in the cap. On the electronic distributor this is usually caused by the wires leading to the pickup unit becoming frayed and interfering with the metal advance plate.

10. The Major Tune Up

A major tune up is something you should have the knowledge and tools to do, or be willing to learn. The procedures described in this section will have you completely "re-set" your car, leaving you with a vehicle tuned to the factory specification and with all new fluids. The idea is that you need your car to a neutral or baseline position before trying to make any additional changes.

10.1 Preparation

Using the information you've already gathered (engine type, head type, etc.) you are already on your way to establishing a baseline for your engine's performance. It is important to get a feel for how your existing setup operates before trying to change anything. All of this work is easy and, armed with a shop manual for your model year; you can do this in a couple of hours in your garage with minimal parts expense.

A suggestion before you begin: if you are new to working on cars or new to your FIAT and note that the overall condition of your car is "worn" then consider the likelihood that the replaceable parts under your hood are also worn. Be prepared to inspect and purchase all of the ignition parts, hoses, shims, and belts. The expense will be minimal and you'll likely transform a "worn" car into one that performs just fine.

10.1.1 Ignition System

As necessary, you will need to install new plugs, wires, distributor cap, rotor, vacuum advance capsule and hose, coil, pickup, points, and condensers, and set the timing, plug and point gaps, and the dwell angle. Set the ignition timing to exactly what your car's instruction book calls for. If you have Marelli electronic ignition (1979-1985) check that the vacuum advance is working properly. For each of these items follow the procedures below.

Spark Plugs: If they look old, grimy, dirty, or anything but clean, replace them. You do not need fancy spark plugs in your FIAT; your best bet is to use stock equivalent plugs (some vendors actually sell the original equipment Marelli CW78LP, CW7LPR, and CW67LPR and FIAT 1L4JR plugs). Spark plug gap for resistor plugs is 0.7 to 0.8mm. *Note: if the spark plugs have a greenish-white crystallization on them you likely have a leaking head gasket that must be replaced before continuing.*

Plug Wires: Brittle, hardened by heat, cheaply made, home-made, or unknown quality wires should be replaced. As with the spark plugs you do not need an expensive set of wires; the stock type works fine. When installing plugs coat the inside of the spark plug boot with dielectric grease available from your auto parts store. If you like original parts the Cavis ignition wires are available from some of the parts vendors.

Distributor Cap: If your cap has any cracks or shows obvious signs of wear on the electrodes then it is time for replacement. Aftermarket caps are sometimes of poor quality; if you can find the original Marelli distributor cap it is always your best bet.

Rotor: Replace with cap or if the wear is excessive. Spend the time to find an original Marelli rotor; they are of much higher quality than most of the aftermarket types.

Vacuum Advance Capsule: The rod from the distributor body into the capsule should pull when the throttle is engaged. Otherwise replace the hose, capsule, or both.

Coil: Test the coil using a voltmeter and the procedure described in the shop manual for your model year. A twenty or thirty year old coil may still be producing good spark – these are very durable devices. Note that the coil in the 1979-85 Spiders must be replaced with the appropriate Marelli unit and never with a coil designed for points-type distributors.

Magnetic Pickup and Control Module: Any wear or exposed wiring should prompt you to replace the unit. The wires on many aftermarket units are longer than necessary, be careful to position them so they do not rub against the moving parts of the distributor. If you are replacing the magnetic pickup you may want to consider replacing the control module; however, the control module is reasonably insulated and has no moving parts near it, it tends to last much longer.

Points: For cars with breaker points, the gap should be 0.31 to 0.49mm and the contacts should be in good condition. Marelli points are available for (at the time of this writing) under $10.00 a set.

Condenser(s): Replace any time you replace the breaker points.

Dwell Angle: The dwell angle is 55 degrees. Check and adjust with the points.

10.1.2 Cylinder Head

The cylinder head should be checked for fluid leaks. If the head isn't clean enough to inspect it then consider cleaning it up with engine cleaner or carburetor cleaner. Check the coolant hoses entering and exiting the head. Remove the camshaft covers. If the oil inside the camshaft boxes is foamy or a milky brownish-black you most likely have a leaking head gasket. You may also have a greenish-white crystallization on your spark plugs. You must replace the head gasket before using this engine.

If everything looks good then check the valve lash:

• Intake :	0.45mm cold
• Exhaust:	0.50mm cold

Adjust, if necessary, by using the procedure described in the shop manual. Good valve lash is essential for engine performance.

10.1.3 Fluids

Coolant: Inspect the cooling system hoses for any cracks or hardness. If the age of the hoses is unknown or the condition questionable then replace them all. Replace the thermostat at the same time unless you are certain it is operating properly. Make sure and check the heater hoses to and from the cylinder head and, on the fuel injected and water choke carbureted vehicles, the small hoses running from the intake manifold and heater pipe to the carburetor/fuel injector plenum. Fill the system with the appropriate mixture of coolant and distilled water.

Keep in mind that the FIAT cooling system is particular about how it is filled. There are two popular procedures that you can do in your garage. Open your heater valve prior to performing either method:

- The first is to place the front of the car on ramps or jacks and get the level of the radiator cap higher than the back of the cylinder head heater hoses (in the back of the head is a black hose that runs up near the #4 plug and then behind the head). Fill the system from the radiator.

- The second method is (in your author’s opinion) the most effective. Using a flush-and-fill kit (such as the Prestone Flush and Fill Kit) install the filler “T” in the cylinder head heater hose. With the radiator cap off fill the system until water comes out of the radiator. Install the radiator cap. Now loosen the brass cap at the radiator hose intersection in front of the head and fill until coolant flows from this point. Tighten and finally top off to the “T”.

Oil: Your FIAT was designed to use a FIAT branded oil called Oliofiat. Oliofiat VS+ 15W-40 was the typical specification for the Spider. The oil carried an API rating of "SE", which at the time was the highest rating for automobile and light truck use. The current rating is "SJ" and any oil in the SAE 10W-30, 10W-40 or 20W-50 viscosity range that carries the current "SJ" service rating will suffice.

Gasoline: If your gasoline is old or questionable then siphon your tank to empty and fill with the highest octane you can purchase from a gas station. Do not use fuel additives.

10.1.4 Filters

Replace the air cleaner filter if it is dirty. On carbureted vehicles replace the fuel filter with a glass type having a replaceable element. On fuel injected vehicles replace the fuel filter with a new Bosch filter.

If you suspect any kind of fuel flow problem remove the fuel tank sending unit and inspect the mesh screen filter inside the tank. There is also a small filter on carbureted engines located inside a large brass nut on the fuel intake assembly of the carburetor (typically on the bottom, refer to your carburetor diagram). It can be removed and cleaned with carburetor cleaner.

10.2 Tuning Procedure

Here are the steps to get your engine tuned to the factory specification. Note that the three steps really just refer you back to the proper section. What is important here is to not go beyond the factory setting. Don't "tune by ear" (yet) or "dial in" anything. The factory spec may not be perfect, but it is neutral.

10.2.1 Basic Engine Timing

Set your crankshaft to top dead center. Check that your camshaft wheels are lined up with the markers cast into the camshaft boxes or the pointers in front of the camshaft wheels. See the ignition section for diagrams and details.

10.2.2 Basic Ignition Timing

Using a timing light, set your ignition timing to the specification for your Spider:

0 degrees	Spiders prior to 1978
10 degrees	Spiders after 1978

See the ignition section for diagrams and details.

10.2.3 Idle Speed Settings

Set the idle speed according to the instructions in the carburetion or fuel injection settings in this guide.

11. Improvements*

* Ask yourself if things need improving.

Performance is a relative term. You need to define how you want your engine to perform so that it suits your needs. A high performance engine is not necessarily fast and a poorly performing engine is not always slow. Lots of car companies state that their engines are "high performance" just because they produce more than "x" horsepower or "y" torque. But look at what these companies do to produce this power - enormous V6 and V8 engines that barely produce ¾ of a horsepower per inch of engine displacement. These can be 350 and 400 cu. in engines producing less than 300 HP. Alfa Romeo and FIAT were producing 1HP per cubic inch of displacement in the 1960's. Sure, the engines produced around 100 to 120HP, but which one is higher performance? It's up to you to define performance in terms of what you want your car to do. Performance is relative to your needs.

Do you want to build a 200HP Spider? It can be done, with a standard FIAT engine block, cylinder head modifications, high compression pistons, lightened flywheel and connecting rods, supercharging, etc. Guy Croft has been building race-prep FIAT twin-cam motors from his shop in the United Kingdom for many years. He wrote a book on the subject (which is now quite hard to find) in case you want to do it all yourself, or you can pay upwards of $8,000.00 to get it done right by Guy personally. Alternatively, there are numerous things you can do with a relatively stock FIAT Spider and really improve your driving experience. The interchangeability of parts between model years allows you to use off-the-shelf FIAT parts to truly transform your Spider.

The good news is that many Spider parts can be interchanged between engine series or upgraded with new parts. These interchanges can be done to improve things such as acceleration, horsepower, and torque. Parts availability and installation ease are both very good; in other words, you may be able to mix and match parts at a minimal expense and create an improved driving experience. This section deals with some improvements that have been proven to be successful in delivering improved performance and reliability.

You should approach performance improvements with some caution. There is a financial trap you can easily fall into, with your improvements quickly reaching the point of diminishing returns. A set of new carburetors, head work, pistons, camshafts seals, rings, and all of the other parts can easily set you back three or four thousand dollars. It is very easy to say "since I'm pulling the motor anyway, I'll go ahead and install new, high compression pistons and those lightened connecting rods." Consider that your tired engine may improve dramatically by rebuilding to stock (or near stock). There are exceptions, such as the Spider 2000 fuel system, but for the most part these cars were very nice performers in stock form, and some relatively inexpensive changes may meet all of your needs.

11.1 Cylinder Head Improvements

We've discussed how the head works in previous sections. Let's talk about the things that impede the efficiency of your cylinder head and how to overcome these performance-robbing issues. We will start by discussing some cylinder head nomenclature then working backwards, from the late model smog heads down to the early Spider heads.

11.1.1 Nomenclature

You may have heard the expressions "porting," "polishing," "matching," and "blueprinting." These are all methods of optimizing the airflow through the cylinder head. Keep in mind that the head is the top of a big air pump (the engine) and the more efficiently air can pass through the pump the more performance you will get from the vehicle.

A head that is ported, matched, or blueprinted has the port sizes on the intake and exhaust manifolds match those on the cylinder head. In other words, the pipes leading out of the cylinder head and the pipes leading into the head do not reduce or have interference in between. The gasket mating the two engine parts has been cut, if necessary, so that it does not baffle the airflow in between. The ports on the exhaust side are matched as well. FIAT heads typically have no resistance between the ports and the gaskets do not protrude into the airflow.

A polished head is one that has had the combustion chambers and ports polished so that nothing in the aluminum may disturb airflow. Polishing to an extreme can be counterproductive as it may eliminate some of the "swirl" that is good for combustion. The good news is that the FIAT heads are usually very smooth and require little or no polishing.

11.1.2 Head Specifics

We'll work backwards from the late model heads to the early types, since the most popular and effective swaps occur more frequently with the late model Spiders. The Spider 2000 fuel injected head is very "clean." The fuel injection system did not require the myriad of pollution control devices found on the carbureted 2000 head. It is essentially a straight head with good combustion chamber size and shape, and good port sizes. If you are curious about the hoses and pipes all over the top of the head they are all related to the fuel injection system and are not actually interfering with the combustion chambers, ports or valves. Fuel injected heads have the same camshaft profile as every other FIAT Spider.

The Spider 2000 carbureted head is an example of what FIAT did to meet EPA regulations. Depending on where your car was sold (California, for example, had different regulations than other states) it may have an EGR bypass that squishes the #1 combustion chamber, reed valves that run into the head and to an air pump, vacuum ports on the intake manifold for various emissions control devices, and, as mentioned earlier, a restrictive exhaust system mated to it. The head, intake, exhaust, and carburetor are collectively regarded as "boat anchors" and are always candidates for replacement. Simply replacing the carbureted 2000cc head with one from a 2000cc fuel injected or 1756cc engine will provide some improvement in efficiency.

The Spider 1756 head began life as a clean head, nearly identical to the 2000 FI head described above. The 1756 head has smaller combustion chambers than the 2000 heads but is otherwise the same casting. By 1978 they had adopted a camshaft-driven air pump and several emission control valves on the intake manifold. Unlike the 2000 carbureted head the 1756 never had the EGR port squishing the combustion chamber and with little work any of the 1756 heads are desirable. One of the Lancia heads, the 1976 Monte Carlo (Scorpion) head, has larger ports than the other model years. The 1756 intake manifold is also desirable for the ADL, ADF, ADFA, DFEV, and DMSA carburetors.

The Spider 1592 head was designed for, and mated to, the 1592cc engine used on the 1973 model year only. It is not laden with any specific emission control devices and is really a clean head. If your vehicle has the 1592 motor (many were replaced with 1756's) and you wish to maintain originality then this is the only head you can use. It is otherwise not desirable for use on any other Spider.

The Spider 1608 and 1438 heads are clean heads with few or no emissions control or other power-sucking devices added to them. They are slightly different that the later series heads and, for the purposes of interchangeability (as described below), should probably be kept on the engine they were designed for.

11.1.4 Interchangeability

The interchangeability of cylinder heads between the 1756 and 2000 Spiders is a true, do-it-yourself, instant improvement. A clean 1756 head installed on top of the 2000 block (carbureted or fuel injected) results in a compression increase. Although not as dramatic as the installation of high compression pistons, this can be done without pulling the engine and requires the same amount of work as replacing the head gasket. The difference being when the head gasket goes on the new head goes on top.

The 2000 FI head can also be installed on the 2000 carbureted engine. It will not alter the compression ratio but will improve performance just by nature of a better, cleaner design.

Other model years can be interchanged as well. The 1438 head is somewhat restrictive and, with some minor welding on one of the coolant ports, can be replaced with the 1608 head. Experience has shown that most owners of these older Spiders are not doing these upgrades as the performance gain is minimal. More suitable is the installation of high compression pistons or other engine upgrades.

11.1.5 Camshafts

The camshafts installed on the 124 Spider are designed for normal road use. They provide reasonable performance and are very durable. Other camshaft profiles are available for the Spider, ranging from “street” to “hot street” to “racing.” If you are considering camshaft replacement you should speak to people who have done this before and understand the sacrifices of changing cams, such as:

- fuel economy may be reduced;
- idle and low speed operational quality may be reduced;
- acceleration may be undesirably jumpy; and,
- it may be impossible to pass emissions testing.

Understand that the camshaft is the engine’s brain. Changing that brain can result in a very different engine. This operation may be very good or very poor for your conditions. The stock cams are reliable, inexpensive, and do not significantly reduce street performance. If you are considering camshaft changes visit someone with a modified Spider and drive it, see if you like the overall operation.

It is important to check that your camshafts are in good operating condition and are not worn. Measure or have the camshafts measured to the spec in your shop manual and, if necessary, replace them. Stock and aftermarket camshafts are available from parts vendors.

If you are new to the 124 Spider or just now considering engine changes, there are stories all over the internet about the European specification 1608 camshaft having a ”better” profile than the later years. A few years ago Allen Lofland, a FIAT and Lancia owner, led a crusade to prove this myth. Several people (myself included) bought camshafts from the European 1608 Spiders. I bought my set right out of a car while living in Europe – so I’m fairly certain of the originality. The cams were studied, measured, inverted, turned, shaken, installed, driven, and…you probably guessed already – it is a myth. The only notable difference in the USA and European 1608 Spider was the installation of one (USA) or two (Europe) carburetors. Certainly there is room for error, and these mythical camshafts may have existed, but we couldn’t find any.

11.1.6 Camshaft Wheels

The cast iron camshaft wheels are extremely durable but very heavy. Heavy engine components will rob some power from the motor. Some of the camshaft wheels are made of industrial-grade plastic, very light but lacked durability. In both cases there is room for improvement. Later model FIAT wheels are slightly lighter as they have a hub-and-spoke construction (they are still iron). Aftermarket wheels can be had in very lightweight aluminum.

Another option is adjustable camshaft wheels. These allow you to independently change the timing of each camshaft to match your requirements. This compensation allows for fine tuning of your engine to a degree not possible with stock components. Some of these wheels require modification of the cylinder head; check with your supplier. Adjustable camshaft wheels will add something new to your engine – complexity. Consider that factor and speak to people who use them before installation.

11.1.7 Big Valves

Many suppliers sell big valves and/or peformance heads (meaning a stock head that has been cut to fit big valves and ported for better airflow). Simply buying the big valves and cutting the head to accommodate them or buying a performance head will not result in any huge performance increase. The fuel delivery system has to be capable of bringing more air and fuel into the combustion chamber. Big valve heads that are ported and matched to a ported intake manifold will allow more air and fuel into the engine. A larger carburetor will also be required on most engines.

11.2 Intake Manifolds

A variety of intake manifolds were installed on the carbureted Spiders. They followed two basic designs as described earlier in this book, dual-plane and single-plane. To recap, a dual plane manifold has two chambers inside of it, one is small and the other is large. The larger one is the primary plenum and services the main throttle of the carburetor. The smaller one is the secondary plenum and services the secondary throttle. Dual plane manifolds are designed for optimal operation of the secondary throttle of pneumatically-operated carburetors. Single-plane manifolds have one interior space. Fuel and air from both throttles is delivered from this one large space into the intake runners and then the combustion chambers.

With the exception of the 2000 series all of the manifolds are quite good. On the 2000 Spider the intake manifold should be used with the ADHA (stock) carburetor only. The casting is such that the secondary throttle opening is too small for any other carburetor. For pneumatic carburetors fitted to the earlier Spiders you should plan to use the stock manifold for the model year and carburetor, for example, use the 1608/1592 manifold with the 28/36 DHSA carburetor.

In all cases it is realistic to block off all of the ports except for the brake booster inlet. Keep in mind that if you plan to keep emissions control devices that rely on manifold pressure you can't block off their ports.

11.3 Ignition

Running with points? There are a few decisions that need to be made about your ignition system if you are looking to improve things. Improvement can often be made by simply making sure your entire ignition system is working properly. Thad Kirk, a long time respected FIAT owner, has articles on points ignitions on www.mirafiori.com. He notes that a well tuned points distributor provides reliability and performance right up there with the electronic system. The trade-off is the older types require more maintenance. If you want to eliminate this maintenance at the sacrifice of originality, you have options.

The 1979-1985 electronic ignition system is a popular and easy upgrade from all previous types (dual and single points). Installation of the late model system is straightforward, you'll need the distributor body (preferably rebuilt fully) in proper operating condition, and the coil pack. The system directly replaces the old components and is tuned in the same manner. There is an economic downside to the electronic ignition system conversion; to make it work properly you must have a carburetor ported above the throttle plates. The stock carburetors with this option are the 32 ADFA and the 28/32 ADHA; the aftermarket carburetors are the 34 ADF, 36 ADL, 38 ADL, and 32/36 DFEV.

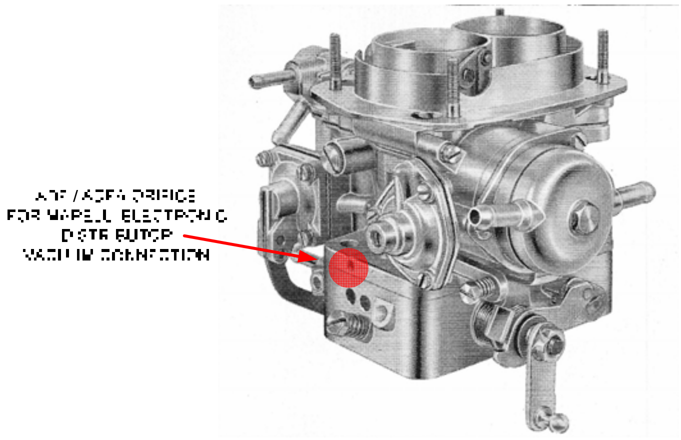


Figure 47: Location of port for vacuum advance

The figure of the ADFA carburetor above shows the location of the vacuum port, on the main carburetor body above the throttle mechanisms. Unlike earlier models these carburetors have a two piece construction and this port is tapped into the base of the upper portion, just above the mixture screw. Without this connection the vehicle ignition will not work properly and performance will degrade below that of the mechanical system you've replaced.

The Marelliplex electronic ignition system is an option for those of us who do not want to find ported vacuum. Marelliplex units are available as block-mounted (for 1438cc motors) and cam-box mounted (for all other motors). Unfortunately, the cam-box mount type is nearly impossible to find and will typically cost more than a new carburetor. The block-mount is more common and shared with the Lancia beta, but will only fit well on the 1438cc and 1608cc motors. There are manifolds for the 1756cc with a slight indentation that will allow the distributor to fit the other motors, but the difficulty of installation (it is almost too tight to tune) may make this undesirable. The block-mount is available new from some parts vendors.

Another option is an optical trigger unit, available from most auto parts stores. These units remove the wearable points in the distributor body. The most popular is the Crane Fireball, sold by many parts vendors. If you are considering one of these units you should speak with other owners on installation specifics, ease of use, and reliability.

11.4 Exhaust and Emissions Control

There are few options in the exhaust improvement category. There are the stock systems that have a four-two-one design, and aftermarket systems of similar design. Unless you have a specific need for an aftermarket design, the FIAT 4-2-1 is efficient, well designed, fits correctly (unlike many aftermarket systems), and has a stock look. For carbureted engines made after 1973 the 4-2-1 type used on the 1756cc Spiders will work well. The 4-2-1 type used on the 2000cc Fuel Injected spider will work on these models as well (although it may hang a little low for 1756cc Spiders).

If you use the fuel injected 4-2-1 exhaust on a carbureted engine note that you will need to block off the oxygen sensor port and, unless you intend to use the catalytic converter and rear section from a fuel injected car, modify the flange under the vehicle for use with the carbureted, 3-bolt catalytic converter. A “full conversion” to the FI 4-2-1 is actually quite easy and saves the hassle of having to cut, weld, or alter the stock components.

The emissions control devices installed on your Spider are probably inoperable. The parts to service these devices are also few and far between. In some cases the pollution control equipment operates so poorly that it can increase emissions. If you are concerned about emissions then it may interest you to note that EPA mandated these devices be installed regardless of whether the engine was within good air quality ranges to begin with. An in-tune Spider engine without modifications to the fuel delivery system is a very clean burning engine; even without a catalytic converter many will pass all but the visual inspection of the vehicle.

There are some emissions control devices that you should probably keep. The charcoal canister, which is designed to absorb the stink of raw fuel, is good to have functioning correctly. It can be “recharged” by simply cutting it open and refilling with activated charcoal (from a fish store). They can also be bought new from numerous sources as the FIAT part was used on various years of other European cars well through the 1990’s. The catalytic converter is another part you might consider leaving intact. Although it certainly consumes some power (it creates backpressure by its very design), newer types are far less restrictive than the original equipment FIAT types.

Keep in mind that some states have laws around smog checks and original equipment. Cars made after a certain year may need to pass emissions tests and visual inspection s to verify that all of the original equipment is in place and working.

11.5 Carburetors

We discussed the stock carburetors earlier in this book. The carburetors were reasonably good matches to the engine size; however, a general rule is that the cars were always slightly under-carbureted. Every time an owner installs a DHSA2 on a car previously fitted with the DHSA1 the performance increases. Simply put, the DHSA2 allows more air into the motor. Every Spider 2000 owner who replaced the ADHA and manifold with a DFEV, ADF, or ADFA has felt his car spring to life. This section deals with good swaps and good new carburetors to install on your car.

Most folks who are considering a carburetor swap will likely stay away from the pneumatic carburetors. Truth be told they aren't as fun to drive; the secondary always lags behind the first regardless of how hard you press the gas pedal. They were designed to deliver the secondary fuel at an "appropriate" time, which is fine for fuel economy and emissions, but not so much for overall driving fun. The pneumatic carburetors are harder to find parts for and their unpopularity in modern applications makes parts availability scarcer every day.

Mechanical carburetor swaps are very easy on the Spiders. The easiest and most popular is done by owners of the Spider 2000. The Spider 2000 owner can buy an 1756 intake manifold and the Weber 32ADFA carburetor and install them in the same locations as the old carburetor. Plug in the fuel lines, distributor vacuum pulse line, cold start hoses, and linkages, and get an immediate performance increase. The two carburetors are externally near identical, meaning that the hoses and other pieces line up nicely. The real gain for the Spider 1756 and 2000 owner is from the other Weber ADF, the 34 ADF. Available new from most parts vendors the 34 is a very large and powerful carburetor with no unnecessary components. It has connections for the distributor vacuum and vapor recovery; otherwise it is just a fine Weber carburetor that adds instant fun to the 2000cc vehicles. The 34 ADF should always be mounted on the 1756 ADFA manifold.

If it fits your budget, consider the following combinations:

Table 11: Engine Component Combinations

Block and Head	**Intake Manifold**	**Exhaust System**	**Recommended Carburetor**
2000cc 2000 FI Cylinder Head Stock Pistons	1756cc	2000cc FI 4-2-1	Weber 34 ADF or Weber 28/36 DFEV
2000cc 1756 Cylinder Head Stock Pistons	1756cc	1756cc 4-2-1 or 2000cc FI 4-2-1	Weber 34 ADF or Weber 28/36 DFEV or Weber 36 ADL

Block and Head	**Intake Manifold**	**Exhaust System**	**Recommended Carburetor**
2000cc 1756 Cylinder Head 8.9:1 or 9.1:1 Pistons	1756cc	1756cc 4-2-1 or 2000cc FI 4-2-1	Weber 34 ADF or Weber 28/36 DFEV or Weber 36 ADL
2000cc 1756 Cylinder Head 8.9:1 or 9.1:1 Pistons Mild Camshafts (40/80)	1756cc	1756cc 4-2-1 or 2000cc FI 4-2-1	Weber 34 ADF or Weber 28/36 DFEV or Weber 36 ADL or Weber 38 ADL
1756cc 1756 Cylinder Head Stock Camshafts Electronic Ignition	1756cc	1756cc 4-2-1	Weber 32 ADF or Weber 34 ADF
1756cc 1756 Cylinder Head Mild Camshafts (40/80) Electronic Ignition	1756cc	1756cc 4-2-1	Weber 34 ADF or Weber 28/36 DFEV
1608cc 1608 Cylinder Head Stock Camshafts Electronic Ignition	1756cc or Dual IDF	1608cc 4-2-1	Weber 34 DMS or Weber 34 ADF or Dual IDF
1608cc 1608 Cylinder Head Mild Camshafts (40/80) Electronic Ignition	1756cc or Dual IDF	1608 4-2-1	Weber 34 DMS or Weber 34 ADF or Dual IDF
1608cc 1608 Cylinder Head Aggressive Camshafts (42/82) Electronic Ignition	1756cc or Dual IDF	1608 4-2-1	Weber 34 ADF or Dual IDF or Weber 36 ADL
1438cc 1438cc Cylinder Head High Compression Pistons Electronic Ignition	1438cc	1438	Weber 34 DMS or Weber 28/36 DHSA2
1438cc No other modifications	1438cc	1438	Weber 28/36 DHSA 2

Figures

Tables

www.artigue.com/fiat