

CARBURETOR: BASIC PRINCIPLES

This article will discuss a very interesting subject: the operation and adjustment of different types of carburetors used on motorcycles.

Otto cycle engines used to power both two and four stroke motorcycles are fed with fuel (normal gasoline, special gasolines for some competition needs or, in some uncommon cases, methyl and/or ethyl alcohol), which is sufficiently volatile and has ignition properties which allow it to be premixed with the combustion air before the combustion is initiated by the spark plug. On the other hand, in Diesel cycle engines, the fuel is less volatile and has ignition properties which require that it be mixed with air only inside the combustion chamber, where the pressure and temperature conditions are such to induce natural ignition. For this reason, the power delivery of diesel engines may be adjusted by fuel delivery alone, without the need to control the airflow.

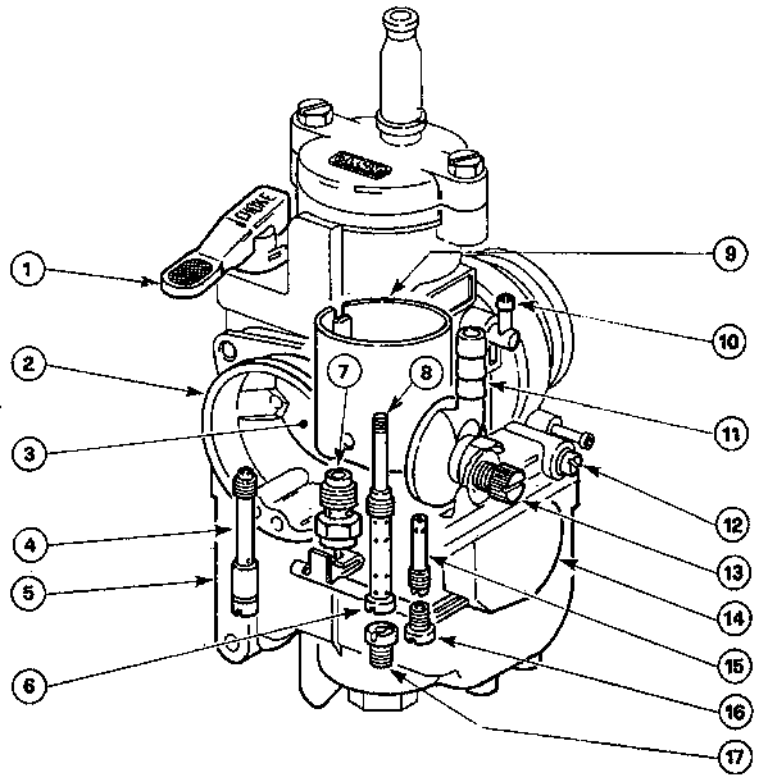
In Otto cycle engines, when the fuel is pre-mixed with the air, it is necessary to control the airflow and therefore, indirectly, the fuel flow. In automobile engines, fuel injection systems are used in most models, controlled by a central unit that adjusts the duration of time during which the injectors remain open to deliver fuel into the air stream. As everyone knows, analogous systems have been adopted on some high range motorcycle engines. In most cases, however, carburetors are widely used, where the fuel is introduced according to the vacuum generated on various systems of fuel jets. The carburetor is therefore designed to perform three



On the right, the main components of a Dell'Orto motorcycle carburetor are shown:

1. starting lever; 2. air intake; 3. venturi; 4. starter jet; 5. float chamber; 6. atomizer; 7. fuel valve; 8. needle; 9. throttle valve; 10. float chamber air intake; 11. fuel connection; 12. Idle mixture adjusting screw; 13. throttle valve adjusting screw; 14. float; 15. idle emulsion tube, 16. idle jet; 17. main jet.

This is a diagram of the gasoline delivery in the inducted airflow: the fuel inside the float chamber rises in the atomizer (31), going through the jet (32) which adjusts the delivery together with the needle (28); the liquid is emulsified first with the air arriving from the channel (13) inside the nozzle (30) then going into the venturi (29) it mixes with the air coming from the intake (1).



basic functions:

1. to control the power delivered by the engine, adjusting the airflow inducted according to driver demand.
2. to meter the fuel flow into the inducted air stream, while keeping the air/fuel ratio in the optimum range over the engine's entire working range.
3. to homogenize the air and fuel mixture in order to make the ignition and combustion proceed properly.

THE MIXTURE RATIO

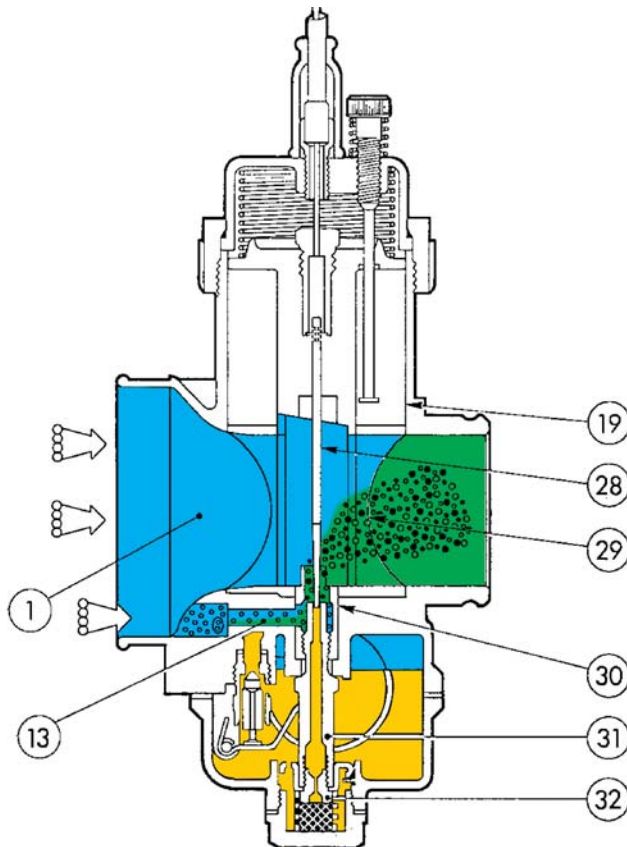
The air/fuel ratio (A/F) is the ratio between the air and fuel mass inducted by the engine. It is defined as:

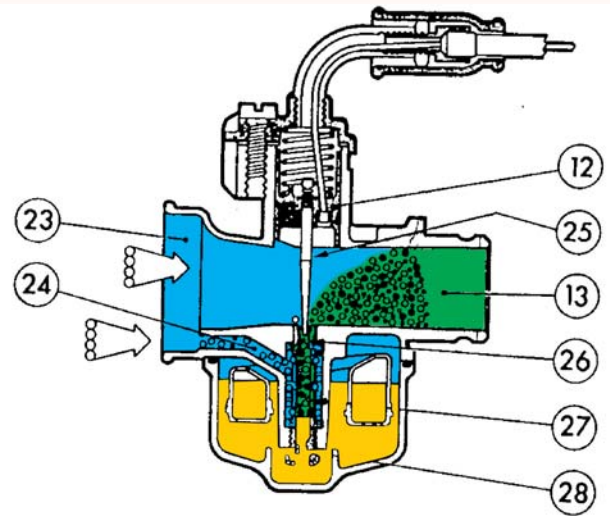
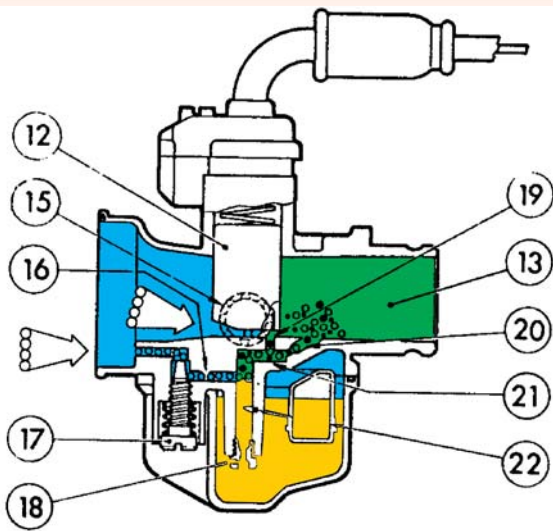
$$A/F = M_{\text{air}}/M_{\text{fuel}}$$

If we consider this ratio from a chemical point of view, the value of the stoichiometric A/F ratio is the one that allows complete combustion, without leaving either excess air (lean mixtures) or unburned fuel (rich mixtures)

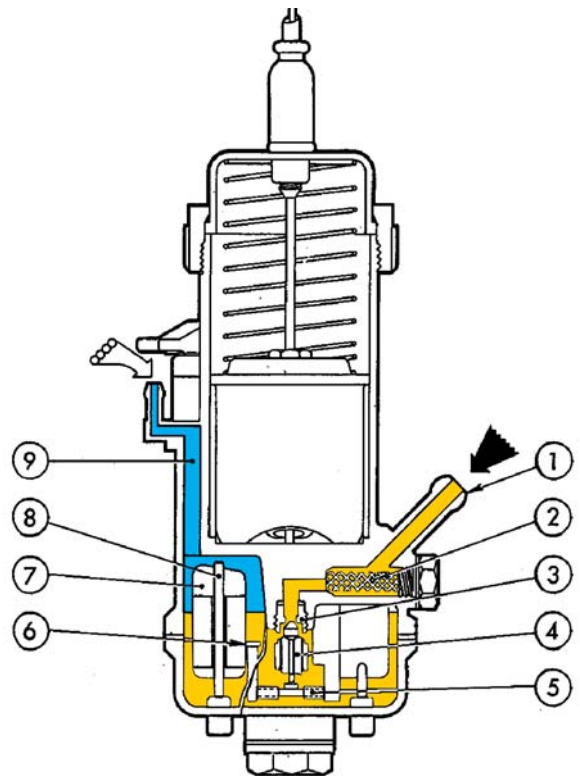
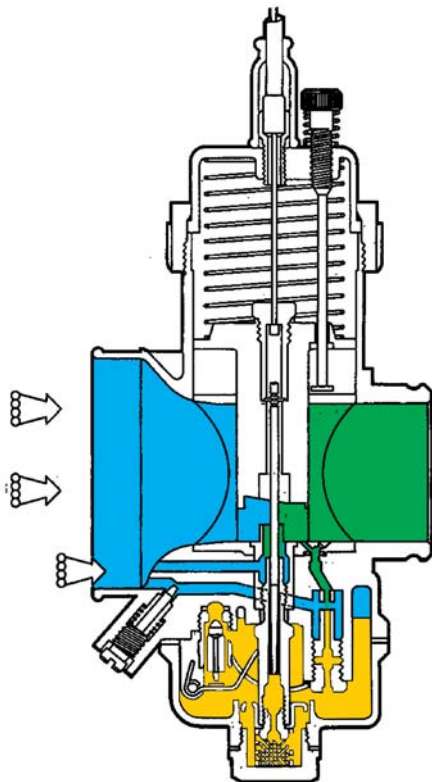
Stoichiometric A/F

The stoichiometric A/F ratio depends on the fuel type. For commercial gasoline this varies from about 14.5 to 14.8, meaning that 14.5-14.8 pounds of air are needed for the complete combustion of 1



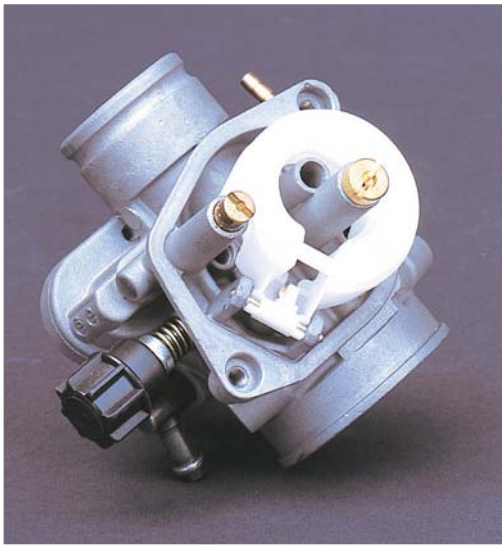
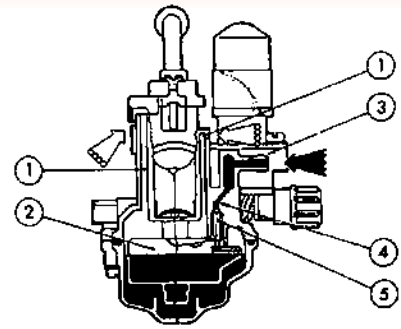
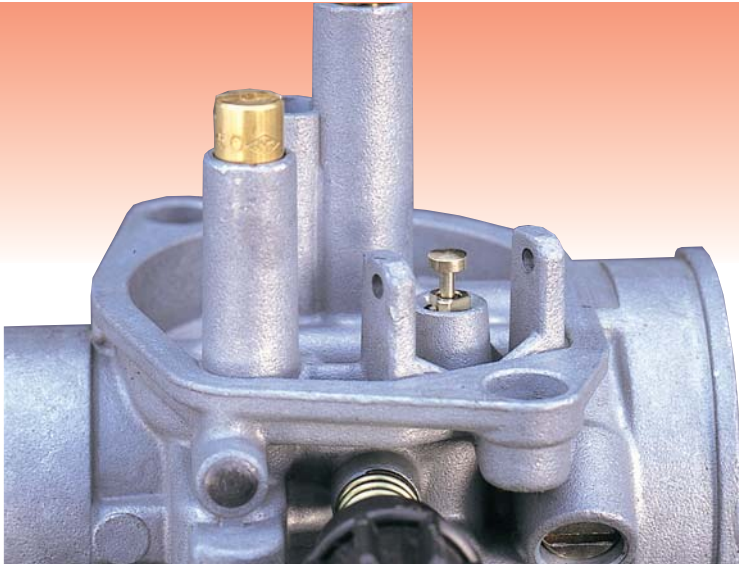


The fuel mixes with the air inducted by the engine by means of different circuits according to the throttle opening. Here above on the left hand side, we can see the operation at idle, with the liquid that is metered by the jet (18) and arrives in the fuel trap (22) before it emulsifies with the air arriving from the channel (16) and adjusted by the screw (17). This emulsion goes under the throttle valve (12) and into the aspiration channel (13) from the ports (19 and 20). On the right hand side, the same carburetor at wide open throttle with the fuel flow adjusted by the main jet (28) that it emulsifies with the air (24) in the atomizer (27) before exiting from the nozzle (26).



A modern needle type carburetor (Dell'Orto VHSB) is equipped with different circuits with relevant calibration jets to assure proper fuel delivery under all conditions. As we can see from the section diagram, each fuel circuit leads to the constant level float chamber.

Section of the fuel feed circuit in a Dell'Orto VHSB carburetor: 1. Fuel line from the tank; 2. Screen filter; 3 fuel valve seat; 4 valve needle; 5 float arm pin; 6. float holder on the arm; 7. float; 8. float driver; 9. float chamber air intake.



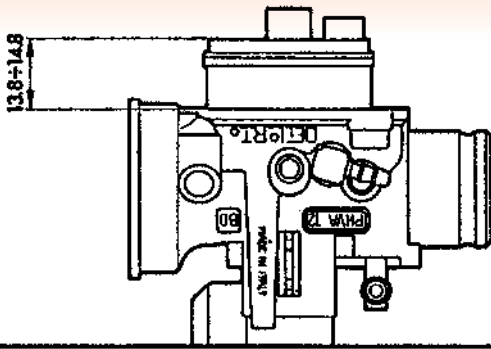
On the left hand side above, the section of an annular float can be seen here above, used on some types of carburetors: 1. Float chamber air intake; 2. Float; 3. Fuel connection; 4. Fuel inlet channel; 5. Valve needle. In the center, a detail of a removable Dell'Orto valve; we can see that the synthetic rubber needle tip is a sprung type. Below a detail of a fuel valve, machined directly in the carburetor's body; in this case the needle is sprung.

pound of fuel. For engines powered with methyl alcohol, this ratio decreases to 6.5 while for ethyl alcohol it is 9.

A/F ratio produced by the carburetor
 The mixture delivered by the carburetor during the engine's operation doesn't necessarily correspond to a stoichiometric A/F value. According to the engine design and its operating conditions (r.p.m. and load) a portion of the delivered fuel may not be burned because it doesn't reach the combustion chamber or because the combustion itself is not perfect. Some charge dilution can also occur from residual exhaust gas remaining in the cylinder, as well as some loss of fresh charge at the exhaust. These effects are particularly sensitive in two stroke engines. If we consider that the appropriate A/F ratio must be that of the charge taking part in the combustion, we can assert that the mixture delivered by the carburetor must be richer ($A/F < \text{stoichiometric}$) to compensate the above phenomena.



Checking the position of the float inside the float chamber is prescribed. According to different carburetor models, the distance of the float from the contact surface of the float chamber needs to be measured

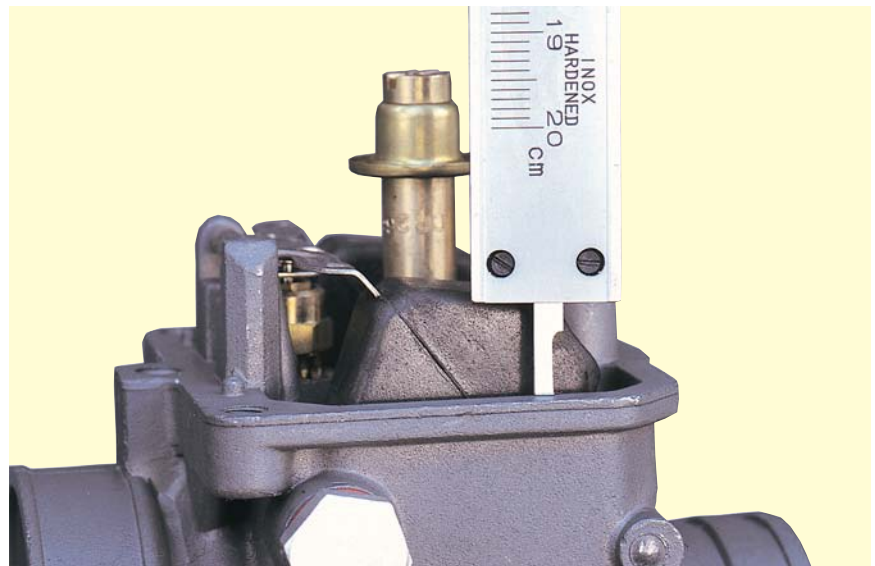


A/F ratio requirement under different conditions

The A/F ratio must vary within certain limits, depending on the engine operating conditions. Generally we can expect that the air/fuel mixture must be richer (A/F lower) at idle, in the acceleration mode, and at full power. On the contrary, at constant load the mixture may be lean, meaning that the A/F ratio can increase compared to the previous conditions. In two stroke engines, the words "rich" and "lean" referring to the mixture, have relative value under different specific operating conditions of the engine, and the stoichiometric mixture is not often referred to, since in these engines the mixtures are always richer than stoichiometric. This may also be partially true in many four-stroke engines, but in general, these engines use leaner mixtures than two stroke engines

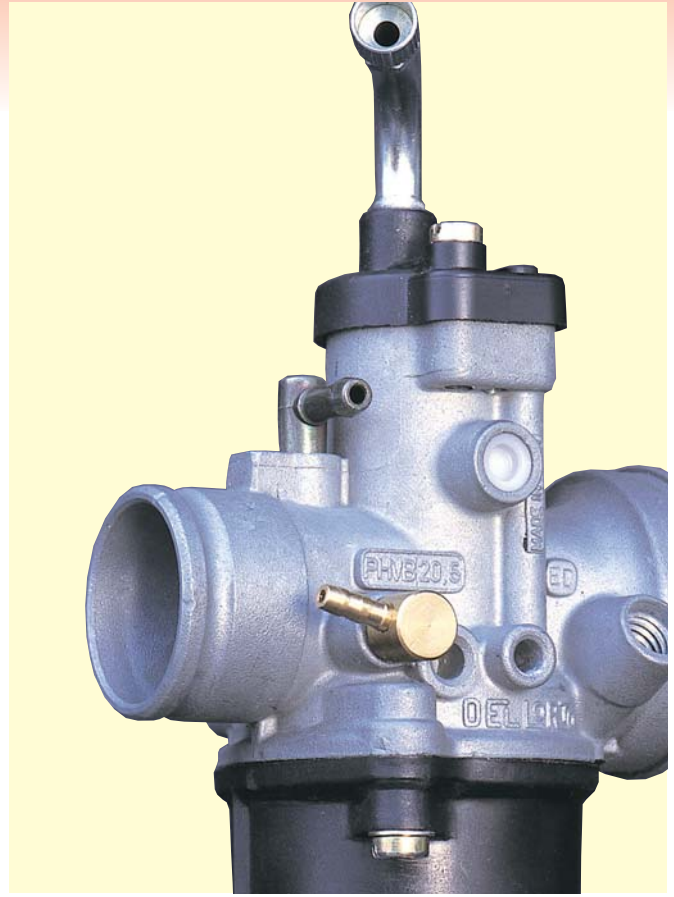
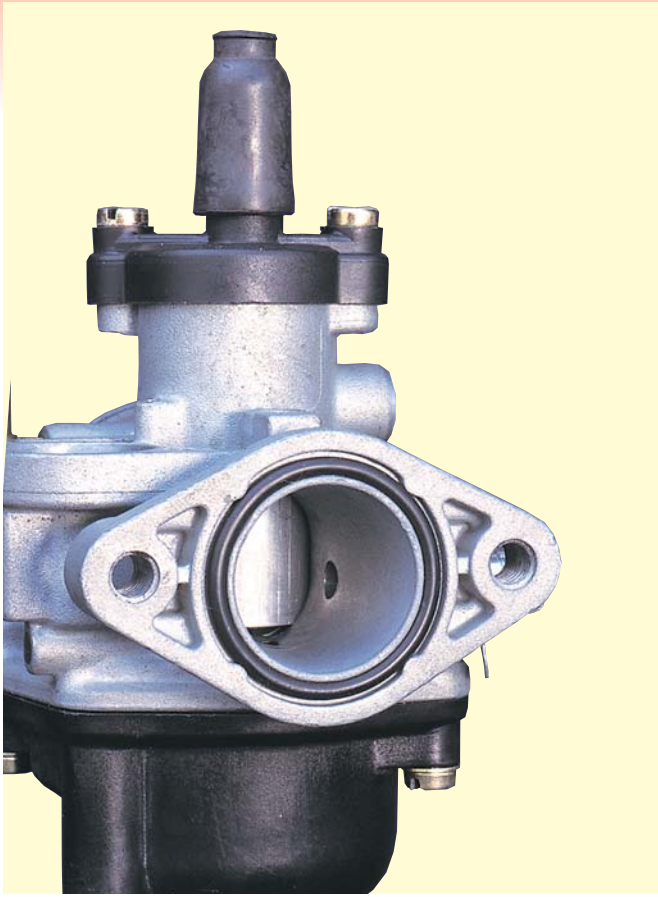
OPERATING PRINCIPLES OF THE BASIC CARBURETOR: THE FUEL DELIVERY CIRCUITS

Liquid fuel is fed to the nozzle of the carburetor venturi, and flows due to the vacuum generated by the air flowing past the venturi itself, and from airflow pulsations generated by the piston movement. The calibrated jets placed upstream of the spray nozzle itself control the fuel flow reaching the spray nozzle. Motorcycle carburetors are nearly always of the needle type and have a structural architecture as shown in the accompanying illustrations. The fuel arriving from the tank is held inside a constant level float chamber. The liquid pressure head on the various jets is relatively constant. The difference between the



float chamber fuel level and the level that the fuel must be raised to by the inducing vacuum remains constant. The float chamber level is kept constant by means of a fuel inlet valve, actuated by a float that follows free surface of the liquid in the float chamber. When the float chamber level drops, due the fuel used by the engine, the float drops and opens the valve, so that additional fuel can flow from the tank. The level of the fuel and float then increases, and at a certain point, closes the valve until the sequence is repeated. The level in the float chamber is therefore a calibration element of the carburetor, since the metered fuel delivery changes with float level, and therefore affects the mixture ratio. By having a high float level, a greater fuel quantity is delivered compared to the case with a low float level, under all operating conditions and for all of the carburetor's circuits. Adjustment of the

float chamber level is affected by two elements: the weight of the float (or of the floats) and the configuration of the lever arm that connects the float with the valve. By installing a heavier float, the free surface of the float chamber liquid must rise before the float buoyancy force balances the increased weight making the float rise. The result will be a higher float chamber level and a richer delivered mixture under the same conditions. On the contrary if we install a lighter float, a lower liquid level will cause sufficient buoyant force to actuate the valve and therefore the carburetor calibration will become leaner. That is why floats are classified according to their weight (printed on them) and calibration standards for their position inside the float chamber are prescribed in order to assure correct operation. To modify the float chamber level, if necessary and when it's not possible to change the



float weight, in some cases it's possible to change the angle of the lever that operates the valve.

In this way, the float closes the valve in advance (for a lower level) or later (for a higher level) at equal weight.

We must note, however, that too low a level in the float chamber can result in an insufficient liquid head on the jets and therefore lead to the risk of dangerous enleanment of the delivered mixture.

This can occur when the fuel moves inside the float chamber due to the accelerations the vehicle undergoes. In these cases (which mainly happen on off-road motorcycles or on the track, in the bends or under violent braking), if the level is too low, one of the jets leading to the carburetor's circuits may be temporarily exposed to air instead of liquid.

In some versions, special screen baffles are applied near the jets.

These are called bottom traps and their purpose is to maintain the maximum liquid quantity around the jets under all possible conditions. A needle that closes on a seat, which is inserted or screwed into

the carburetor's body, forms the fuel valve. The needle is equipped with a synthetic rubber element on the tip.

This material is perfectly compatible with normal commercial gasoline but in the case of special fuels such as those containing alcohol, it is necessary to verify the compatibility of the fuel and the seals in order not to compromise the carburetor's functionality.

Different versions of the needles are equipped with a sprung tip in the connection with the float, in order to reduce the needle's vibration induced by the motion of the liquid in the float chamber and from the motorcycle's movements.

The diameter of the needle valve is a calibration element since it determines the maximum fuel delivery rate.

If the diameter is too small to accommodate the fuel quantity that the engine requires under certain conditions (generally at full load) the float chamber empties faster than it can be replenished through the needle valve! If this condition should continue for some time, the

Carburetors can have different types of flange connections to the engine, according to their use. On the left we can see a flat flange with a seal O-ring; on the right we see a male sleeve required for mounting inside a flexible coupling.

engine suffers from reduced fuel delivery due to the fact that the level in the float chamber is decreased and therefore the carburation has become too lean.