Understanding and improving the slow speed operation of the Mk1 Amal concentric carburettor.

By

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Summary

The Amal concentric Mk1 was the carburettor most likely to be fitted to a British manufactured motorcycle from the late 1960s to the early 1970s. It has a good reputation for simple and reliable operation and is straightforward to tune given a basic understanding of its design. However, low speed and off idle performance can vary, leading to hesitation and stutter in some circumstances. This paper looks at why that might be and suggests ways, using example from more modern carburettors, of how performance here can be improved.

Slow speed fuelling requirements

The performance and satisfaction gained from a classic motorcycle is often judged in large part by its ability to work well at low throttle openings and in traffic at slow speeds. Nowadays, classic bikes are often compared, unfairly in my view, with modern vehicles which are microprocessor controlled with closed loop feedback systems. These modern systems ensure that the engine will start, hot or cold and in the extremes of winter and summer. How well classic bikes operate in these conditions is almost always a compromise and relies on the fuelling supplied by a carburettor designed in the early 1960's.

The carburettor can be considered as containing two separate carburettors. They are the pilot jet system and the main jet systems. The diagram below (fig 1), taken from the Haynes Motorcycle Carburettor Manual printed in 1980, is a useful graphical representation of the fuelling requirements of a classic engine. The specific operation of the pilot jet and the transition of fuelling to the main jet are considered in detail in this paper.

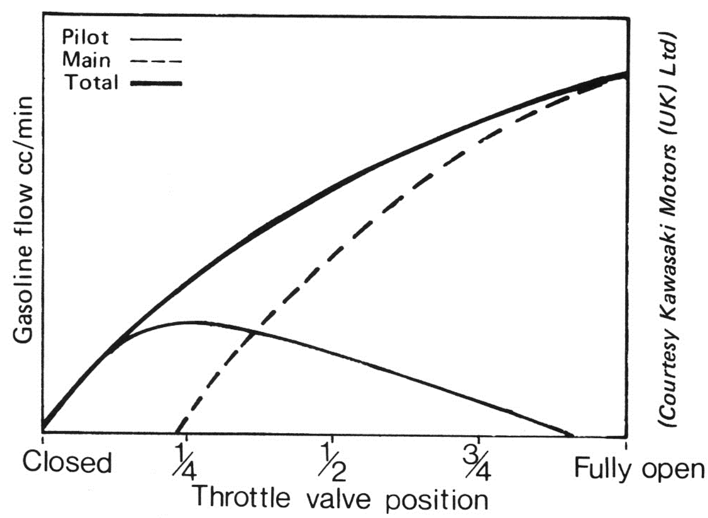

Fig 1. Basic fuelling requirements from closed to open throttle

Fig 1 shows how in the ideal carburettor there is a smooth transition from pilot jet to main jet. Knowledge of Amal operation means that this picture can be redrawn in order to more accurately reflect the actual performance of the Amal Mk1 concentric in practice, where the main jet systems come in to operation slightly earlier. See fig 2.

The initial operation of the main jet circuits is dependent on three specific carburettor elements. These are: 1) the design of the spray tube; 2) the size of the needle/needle jet and 3) the throttle slide cut-away. Of these elements, a larger needle jet and a smaller slide cutaway will create a richer mixture at low throttle openings. The spray tube is fixed and is selected for the type of use, for example 2-

stroke or 4-stroke engines as well as some additional versions for specific applications e.g. the Triumph Trident (incl. BSA R3) and Norton Commando.

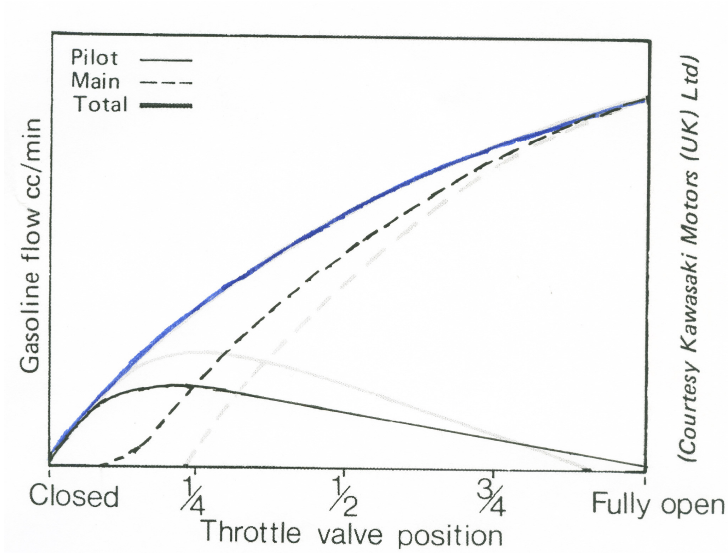

Fig 2. Basic fuelling port transfer for the Amal concentric

Without a pilot jet, the Amal concentric (and all other similar carburettors) will only work at higher throttle openings with the main jets coming into operation from about 1/8th throttle. This effect is often experienced by owners who return to use their bike after a considerable lay-up period. The pilot jet has become blocked with gum and varnish from the stale and evaporated fuel and the engine will then only run with the choke on (choke slide lowered) and won't tick over at all below about 2000rpm.

With the introduction of the Amal Premier carburettor, this problem now has an easy solution because the pilot jet can be removed for thorough cleaning. Once the cleaned and unblocked jet is reinstalled into the carburettor, proper engine performance is restored.

A pilot jet is therefore essential for smooth operation at idle and low throttle openings. It must be able to adequately fill in the missing area of the fuelling curve from idle up to about 1/8th throttle. See figs 1 and 2.

If it doesn't supply enough mixture, then a dip in the performance can be expected as highlighted in the fig 3 below, indicated by the shaded/red area on the fuelling curve. The result can be hesitant running and stutter off-idle and at low engine rpm.

Because performance in this part of the throttle range is so important to a satisfactory riding experience, classic bike owners will spend much time adjusting and readjusting the carburettor, in particular the idle mixture screw and throttle slide cutaway. Sometimes it is virtually impossible to obtain satisfactory performance and the classic bike owner has no option but to accept things as they are.

The concentric idle jet system in detail

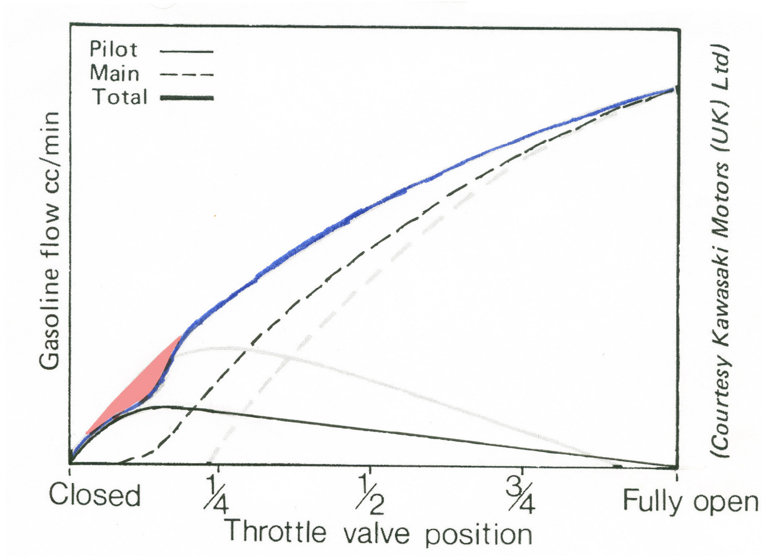

Fig 3. Fuelling port transfer for the Amal concentric with poor outlet positioning

The carburettor design and manufacturing process places the pilot outlet port and transfer port very close to the trailing edge of the throttle slide. With the throttle slide closed at idle speeds, the pilot outlet port is in turbulent airflow. This reduces the efficiency and consistency of the port and is one cause of poor fuelling, hence a 'flat spot' is often present at just off idle. As described earlier, classic bike owners will sometimes compensate for this by using a throttle slide with a smaller cutaway, and a slightly richer mixture. This will have the consequence of making the mixture too rich at slightly greater throttle openings.

The manufacturing process for the pilot outlet and bypass ports on the current carburettor is relatively straightforward and is done from the underside of the carburettor. The outlet port is 28 thou in diameter and the bypass port which is upstream of the throttle slide trailing edge is 38 thou in diameter. These are both machined prior to the fitting of the aluminium welch plug which is pressed into place to seal the idle mixing chamber.

For practical operation, the pilot port and fuelling system only needs to be large enough to cope with the fuelling requirements up to the point of transfer to the main jet systems. If it is too large, it will not be possible to use the throttle adjustment screw to reduce the revs to a satisfactory tick-over speed which is usually in the range 600 - 1000rpm.

The effect of the turbulence and consequent inconsistent performance can be reduced by moving the pilot jet outlet port further away from the throttle slide edge. This can be done using similar machining which is standard on the Mk2 and Mk1.5 Amal concentric. This pilot port layout is also employed in Mikuni and Dellorto carburettors.

For this modification to be done to the Mk1 concentric, a separate machining process is needed. The revised pilot outlet port must be machined from the engine side of the carburettor through the main bore at an angle of 30 degrees. The original hole diameter of 28 thou is used and this is counter-bored to a diameter of 3.2mm. A smaller counter-bore must be used on the 600 series due to physical size limitations of the casting.

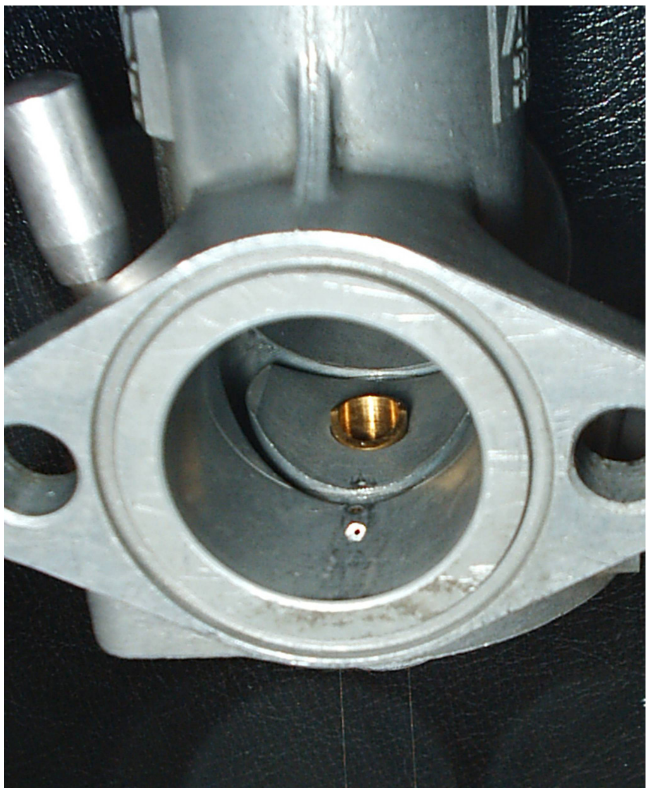

Fig 4. Modified pilot outlet port on a 627 carburettor

Fig 4 above illustrates the modification carried out on a 627 carburettor as fitted to the Triumph Trident and BSA Rocket III motorcycles. The aluminium welch plug must be removed and the new outlet port machined from the manifold face end of the carburettor. The original vertical outlet is permanently blocked off using a pressed in brass plug. Once this machining is done a new welch plug is fitted.

The effect is to enable a slightly greater quantity of mixture to flow much more consistently. The pilot mixture screw has to be opened further (about ¼ turn) than usual to allow for the slightly increased flow from the repositioned outlet port. It thus fills the fuelling void so common to many Mk1 installations.

Airflow over the pilot jet outlet

In the standard carburettor, the pilot jet outlet port is close to the training edge of the throttle slide. The distance is closer on the 600 series at about 1.5mm and is about 2mm on the 900 series. The depth of the throttle slide groove in the floor of the mixing chamber is a little under 1mm deep and about 2.5mm wide. See Fig 6.

These features are very close together and surface friction as well as localised turbulence results in local air flow that is not truly representative of the air stream velocity. Moving the pilot outlet further downstream moves it out of the worst of the turbulence. In addition, the increase in area over which the flow of air acts on the pilot jet outlet makes for a more consistent mixture delivery to the engine.

Another benefit which is probably of lesser importance is that the new arrangement avoids the 90 degree change of direction for the mixture as it exits from the original outlet. This also contributes to maintaining a consistent flow of fuel and air into the engine at smaller throttle openings.

The effect of the modifications in practice

The modifications described above have been carried out on 4 sets of carburettors.

Three 627 carburettors have been upgraded and fitted to a 1972 Triumph Trident. The bike was instantly transformed, most noticeably at the off idle point and will now pull cleanly are reliably from 1500rpm and has an improved on-off throttle performance. Idling performance is also improved.

2 sets of 930 carburettors have been upgraded and fitted to my 1971 BSA A65. The first pair was standard with a pressed in pilot jet bush. Pick-up from slow speed and idle performance are both improved over the standard arrangements. A second set of the new Premier 930 carburettors has also been upgraded and perform in a similar way.

A single standard 928 carburettor fitted to my 1968 BSA B25 Starfire has been upgraded and the improvements in low end performance and idle are noticeable and are similar to the Trident and A65.

All three of the above bikes have analogue electronic ignition fitted which makes them a little sensitive at slow idle speeds and consequently idle is set at around the 800-1000rpm mark.

The effect of ignition timing at low rpm

The ignition timing has a very noticeable effect on the idle performance, in particular idle stability and the ability to set the idle at the desired rpm. The diagram below has been included to show how the timing of the original mechanical A/R mechanism, electronic analogue and electronic digital systems can vary.

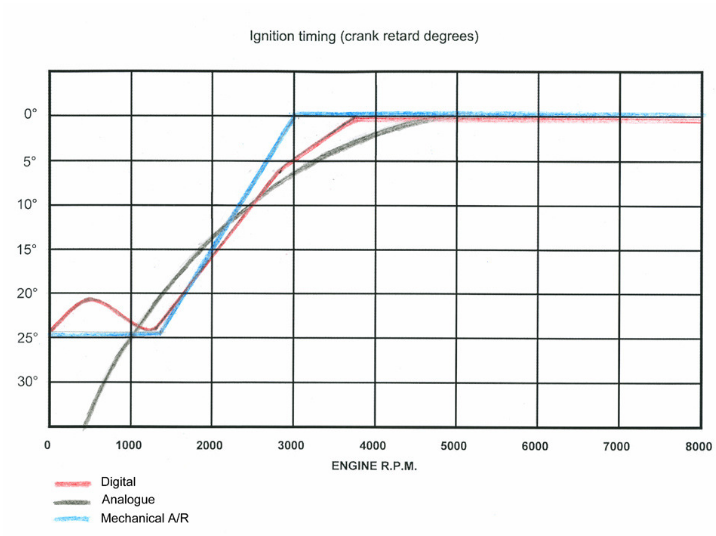

Fig 5. Ignition advance with mechanical and EI systems

The latest digital electronic ignition (EI) systems are a close match to the original points and mechanical A/R systems. Advance curves for some specific models have been developed and are 'downloaded' to digital systems with the intention of making improvements over the original mechanical system. They can also incorporate an 'idle stabilisation' option (included in the digital curve drawn in fig. 5) which introduces a reverse slope at idle speeds.

The big problem arises with the older analogue systems. As can be seen in Fig 5, the slope continues to retard the ignition timing throughout the idle speed range. Note the engine (any engine) at idle speeds will slow down as the ignition timing is retarded. Consequently if the engine is even faintly inconsistent or unstable and as a consequence slows slightly while idling, the ignition retards and slows the engine down further. This problem is more apparent on a tuned single cylinder engine (such as my 250cc B25 Starfire) than it is on engines with multiple cylinders.

If you ever wondered why your engine, even after meticulously setting it up, would tick over more and more slowly, eventually stall <u>and</u> you have an analogue EI, now you know why.

Modifying the 600 & 900 series carburettor

Below are the drawings for the 600 series Mk1 concentric (*Fig 6*). Modifications to the 900 series (*Fig 7*) are virtually identical although slightly easier because the 900 series has more metal in the area of the new pilot outlet port.

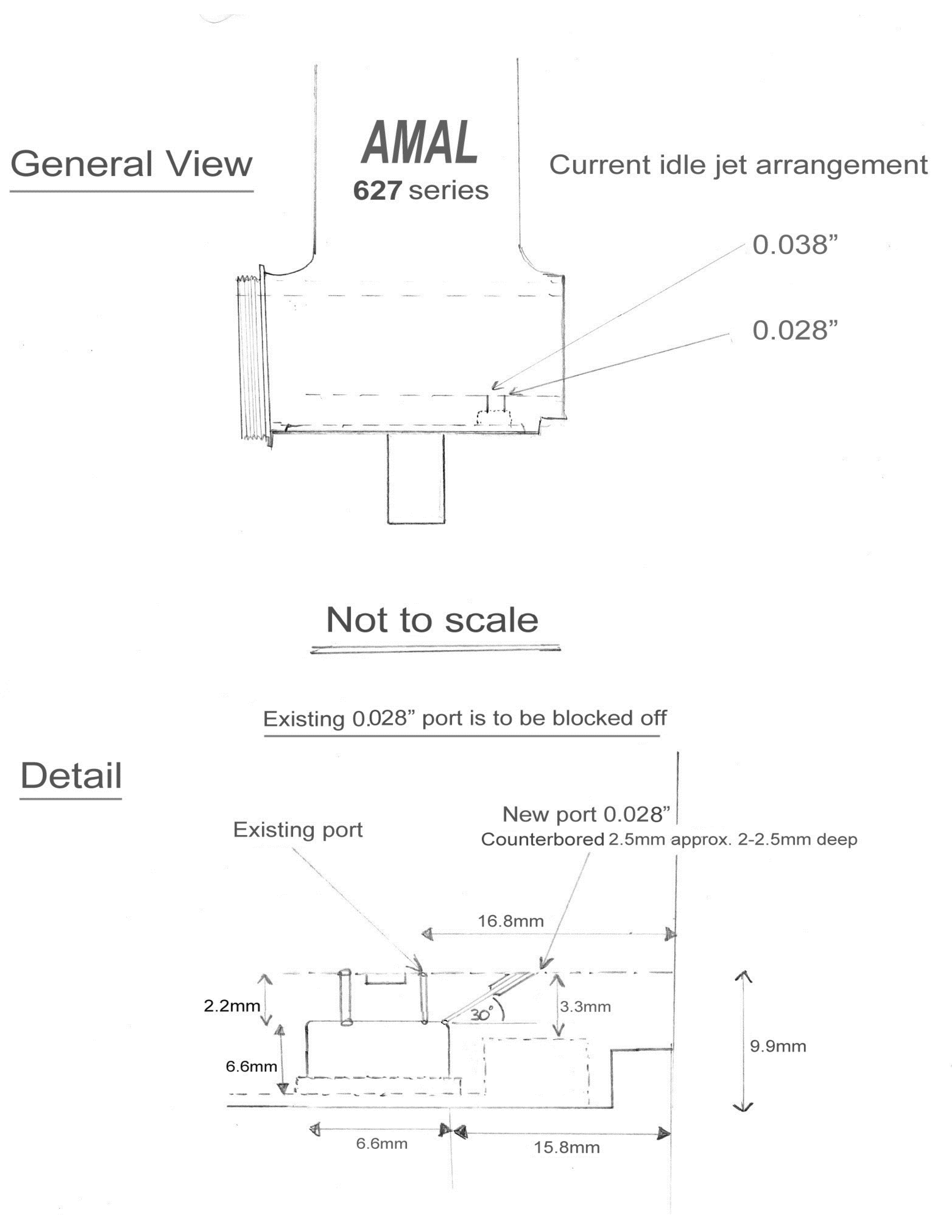

Fig 6. Pilot output port modifications to the 627 carburettor

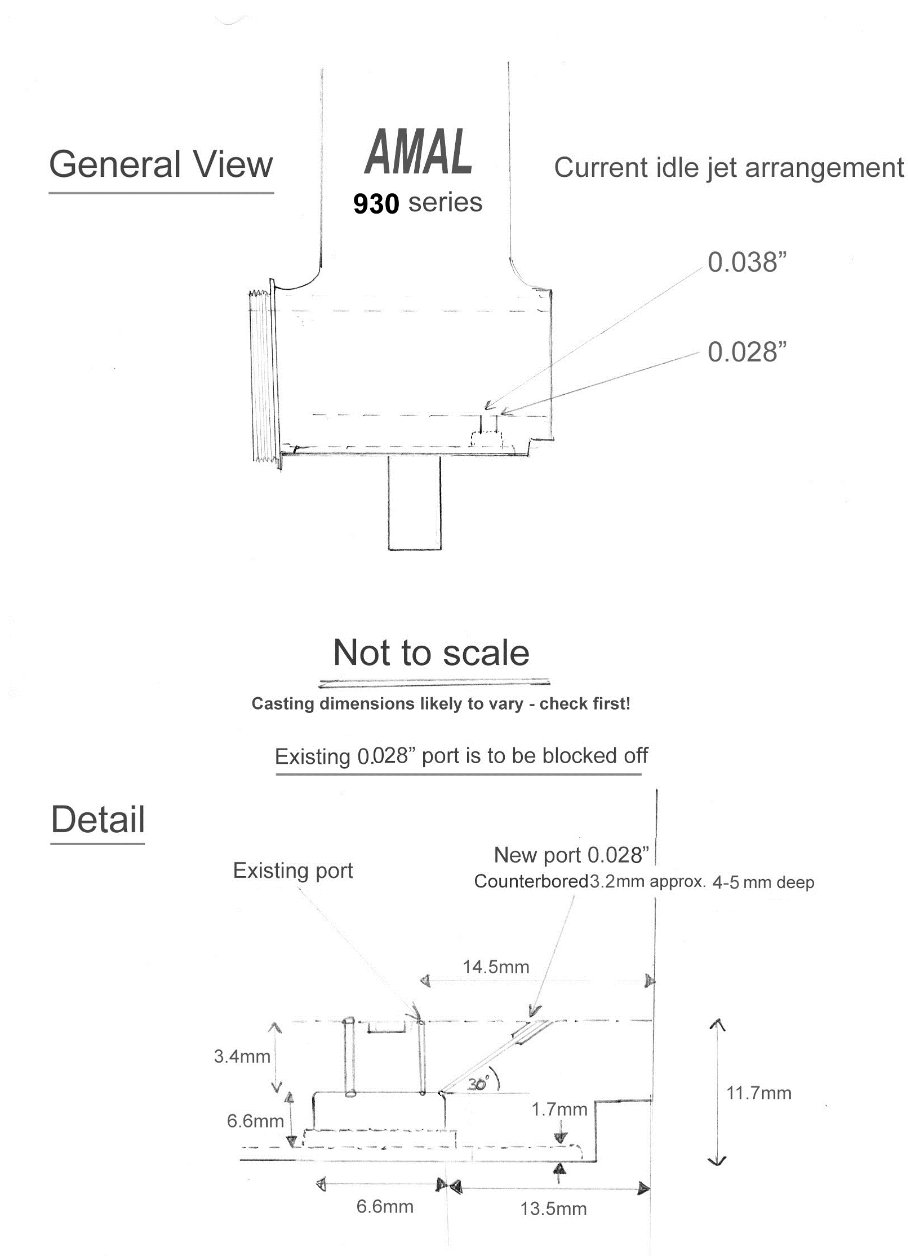

Fig 7. Pilot output port modifications to the 930 carburettor

Comparisons with other carburettors

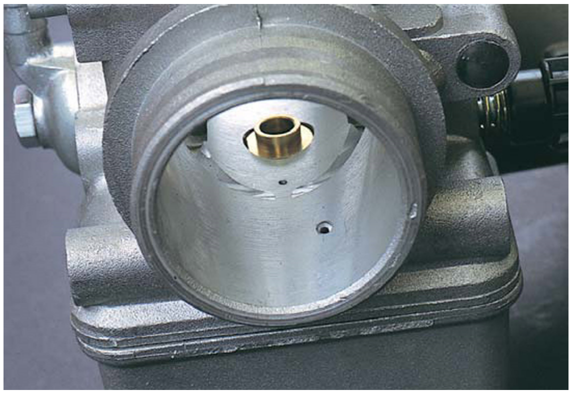

Fig 8. Pilot outlet arrangements - Dellorto

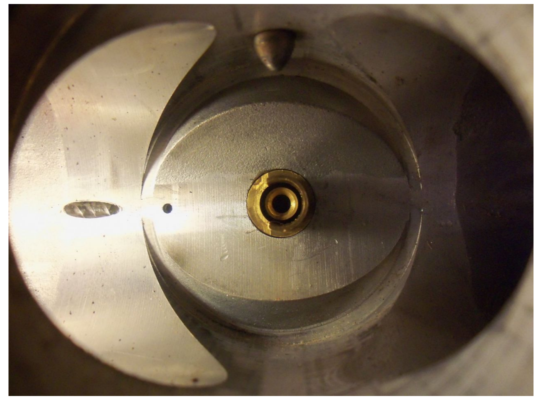

Fig 9. Pilot outlet arrangements – Mikuni VM38

More recent carburettors from Dellorto and Mikuni feature the angled main outlet – see fig 8 and 9.

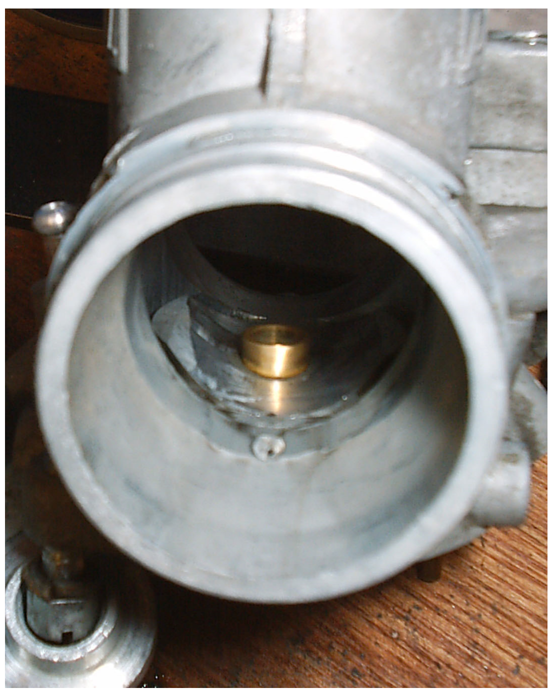

Fig 10. Pilot outlet arrangements – Mk1.5 Amal concentric

And finally the Amal Mk1.5 which is very similar to the Amal Mk2 (Fig 10). Clearly this revised arrangement, having been adopted by so many manufacturers, including Amal themselves for their later carburettors, indicates that there was a strong reason for its introduction.