TUNING TWIN SU CARBURETTORS: PART 2
BALANCING THE CARBURETTORS AND ADJUSTING THE MIXTURE
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My article was first published in Rapier News, the newsletter of the Rapier Register. Some recommendations and dimensions may be specific to the Lagonda Rapier but the principles are applicable to any twin SU carburettor application.

Balancing and adjusting the mixture require that the carburettors have been properly prepared beforehand. I strongly recommend that tuning is not attempted until the manoeuvres described in Part 1 of this article have been completed.

Having prepared the carburettors as described in Part 1, now re-connect the fuel pump and check for leaks. At this stage the choke and accelerator levers should not be re-connected. Start the engine and allow it to warm up. If starting is difficult, richen the mixture by lowering each jet by an equal number of flats until the engine starts, then raise them in equal increments until the engine runs without "hunting". The height of the jets will be fine-tuned later, after the carburettors have been balanced.

Balancing the carburettors
Balancing, or synchronising, is a matter of arranging that for a given depression of the accelerator pedal, air flow through both carburettors is equal. The flexible coupling which connects the carburettor spindles, should be left loose, allowing each carburettor to be adjusted independently. Airflow at idle is adjusted by turning the idle screws to open or close the butterflies. When air flow at idle has been equalised, the flexible coupling connecting the spindles can be tightened.

<u>Listening method</u>
The simplest, and least accurate, method requires only a short length of rubber tube. Start the engine and hold one end of the tube to your ear and the other end just inside the intake of one carburettor (Figure 2). Now move the tube to the other carburettor and compare the loudness of the "hiss". Adjust the idle screws until the hiss is equal, then tighten up the nuts on the clamps connecting the butterfly spindles. Finally, turn both idle screws by the same amount to fine-tune the desired idle speed. Experts apparently develop an "ear" for induction hiss but, for mere mortals, this is an inaccurate method.

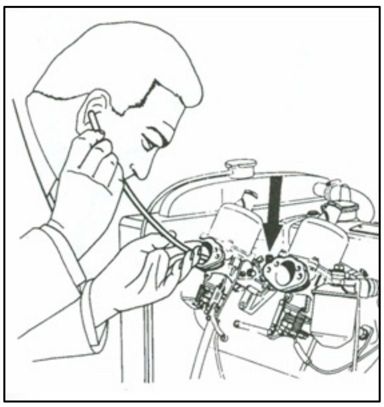
Figure 2. Listening to air flow through the carburettors

Piston height method

When the airflow through both carburettors is the same the pistons should rise to the same height. Remove the caps from the suction chambers (the engine will run perfectly well without the caps and/or dampers for the purposes of measurement). Attach a piece of stiff wire, bent into an “L” shape to each steel piston rods so that the horizontal arms point towards each other. Air flow is balanced when the indicators are level (Figure 3). Some ingenuity is required when attaching the indicators to the solid piston rods in early carburettors*.

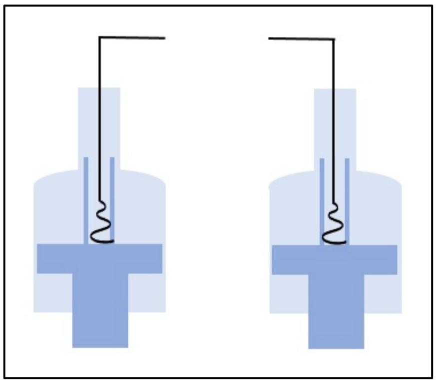

Figure 3. Piston height indicators

Air flow meter method

The reduction in pressure at the carburettor inlets varies according to the airflow through the carburettors. Several airflow meters use this relationship, and each has its devotees. The device is moved back and forth from one carburettor to the other so that air flow can be compared. Some are arranged so that a small bobbin rises up a transparent vertical tube (Figure 4).

Figure 4. Bobbin-type airflow meters

Other devices use a vaned rotor which moves a pointer against a scale (Figure 5).

Figure 5. Rotor airflow meter

A more accurate method is to use an inexpensive battery powered anemometer (Figure 6) with the addition of a large rubber “O” ring glued to the case so that it makes a seal when held firmly against the carburettor inlet. In my experience this device works exceptionally well and gives very reproducible results. The electronics can become confused by electrical interference from a nearby magneto or distributor unless the anemometer is shielded with aluminium foil taped to the back of the case.

Figure 6. Hand held anemometer

Finally, when you are confident that the airflow through the carburettors has been equalized by adjustment of the idle speed adjustment screws, tighten the flexible coupling, then set a relatively fast idle speed by turning the idle screws exactly the same amount. Connect the accelerator lever and re-check that the air flow is equal in both carburettors at higher engine speeds by adjusting the hand-throttle*. At this stage, the engine will probably not run smoothly until the mixture has been adjusted, as described below.

Adjusting the mixture
SU carburettors are pleasantly simple: to adjust the mixture it is only necessary to raise or lower the jet. I describe several DIY methods below, deliberately excluding “rolling road” tuning. Again, I emphasise that the carburettors should be properly prepared before proceeding to adjust the mixture.

<u>Sparking plug inspection</u>
Probably the oldest method of establishing whether the mixture is correct is to look at the colour of the sparking plugs after a road trip of sufficient length to get the engine up to temperature; the longer the better. The engine should be switched off immediately on returning to base and not be allowed to idle before looking at the plugs. Examining the

sparking plugs will provide a rough estimate of whether the mixture is rich or weak and which carburettor(s) should be adjusted. It is generally held that a light brown “digestive biscuit” colour is desirable; black-ish indicates too rich and white-ish too weak. In the case of a white appearance, it may be difficult to distinguish between a very weak mixture and an over-heated (too “soft”) sparking plug. The colour of the end face of the threaded portion to which the outer electrode is attached is said to be more diagnostic than any other part of the sparking plug as it is less influenced by its heat range. If the sparking plug is black, it may be difficult to make a distinction between very rich mixture and oil-burning. Fortunately, there are more accurate ways of assessing the mixture.

Piston Lift Test

The piston lift test (PLT) is the most commonly used method. It assesses the mixture under no-load conditions and at low engine speed; two significant limitations. Manually lifting the carburettor piston by a very small amount and keeping it there for a few seconds upsets the normal relationship between air flow through the carburettor and the amount of petrol drawn up through the annular orifice between the needle and the jet, causing the mixture to become transiently weaker. The important words here are “very small amount” and “transiently”. The observed effect on engine speed determines the adjustments that should be made to the height of the carburettor jets. First, check that the choke is completely inoperative by disconnecting the choke levers and ensuring that the jets are hard up against their adjusting nuts – I have been caught out in the past! A third limitation of this method is that the response of the engine to a PLT depends on how far the piston is lifted. It is usually stated that this should be 1/32 in (30 thou or 0.8mm)[2]. Later SU carburettors are equipped with lifting pins but it can be difficult to ensure accurate and reproducible piston lift.

In the case of an engine with a single SU carburettor, interpretation and adjustment is relatively simple (Table 1).

Response to piston lift	Interpretation	Action
Persistent rise in engine revs	Mixture too rich	Raise the jet until response correct
Engine revs fall and engine may stall	Mixture too weak	Lower the jet until response correct
Engine revs rise transiently	Correctly adjusted	None

Table 1.

In the case of twin carburettors linked by a balance pipe or an adjustable orifice (as we have in our Rapiers*), or if there is a single “plenum” inlet manifold (common in pre-war MGs), *both* carburettors contribute to some extent to the running of *all* the cylinders, and things are more complicated. Each carburettor encroaches to some extent on the territory of the other. For example, in adjusting the front carburettor to produce the correct PLT response, that carburettor could be made excessively rich if the rear carburettor happens to be too weak. This “one-weak/one-rich” situation could easily arise unless a slightly more sophisticated method is employed, as follows:

1) Perform a PLT on the front carburettor and make a note of the response *but don't adjust the jet.*
2) Perform a PLT on the rear carburettor and make a note of the response
3) Adjust the carburettors according to Table 2
4) Repeat steps 1, 2 and 3 as many times as necessary until *one* of the carburettors shows the correct response, ie the engine revs rise transiently
5) *Leave the carburettor with the correct response alone*. Test the other and adjust that carburettor according to the response, using Table 1
6) Make a final test on the other carburettor which may now need a small adjustment

Response to Piston Lift		Action	
Front carburettor	**Rear carburettor**	**Front carburettor**	**Rear carburettor**
Persistent rise in engine revs	Persistent rise in engine revs	Raise the jet by one flat	Raise the jet by one flat
Engine revs fall and engine may stall	Engine revs fall and engine may stall	Lower the jet by one flat	Lower the jet by one flat
Persistent rise in engine revs	Engine revs fall and engine may stall	Raise the jet by one flat	Lower the jet by one flat
Engine revs fall and engine may stall	Persistent rise in engine revs	Lower the jet by one flat	Raise the jet by one flat

Table 2.

In a 1933 publication, Cecil Kimber made an interesting point. If lifting the first piston produces *no discernible effect* on engine revs, it is an indication that the engine is running on the other carburettor alone which is running too rich. Thus, if lifting the front piston has no effect on engine revs, the rear carburettor must be weakened, after which try again. This interdependence is something that should be borne in mind and is the reason why no action should be taken until a PLT has been performed in *both* carburettors (Table 2).

Gunson "Colortune"

The Gunson "Colortune" (Figure 7) is a popular device that acts as a transparent sparking plug through which the colour of the ignited mixture can be observed for a few minutes at a time. A yellow colour indicates a rich mixture and blue/white signifies a weak mixture. I have found that it is preferable to start with a deliberately weak mixture (blue) then gradually lower the jets, unscrewing the jet-adjusting nuts by equal numbers of "flats" until yellow flashes just start to appear. The Colourtune has the advantage that the combustion colour in each of the cylinders can be observed separately. This is also a no-load test, but the engine can be "revved" briefly to assess the mixture within a wider rev range.

Figure 7. Gunson “Colortune”.

<u>Exhaust gas monitoring</u>
A shortcoming of all the methods so far described is they give an assessment of the mixture with the car sitting in the garage with no load on the engine. The mixture can be assessed in real time under varying road conditions by continuously measuring the amount of oxygen in the exhaust gases that has not been consumed by combustion. Modern cars use at least one oxygen sensor in the exhaust system to optimise the amount of fuel injected into the cylinders. These sensors are commonly called “lambda sensors”. Lambda refers to a coefficient describing how far the prevailing calculated air/fuel ratio is from the “ideal” value of 14.7. If lambda is less than 1.0, the engine is running rich, and if greater than 1.0, the mixture is weak. The voltage produced by the sensor(s) varies very rapidly according to the oxygen content of the exhaust gases. In modern cars the engine’s Electronic Control Unit responds to the fluctuating voltage by continually adjusting the ratio of air to fuel entering the engine.

Lambda sensor kits are now available for cars like ours, incorporating a gauge positioned within view of the driver that displays either the lambda number or the equivalent air/fuel ratio (Figure 8). I prefer the gauge to display the air/fuel ratio rather than the lambda value – it seems more intuitive. The kits require only a threaded bush to be welded in position about two feet distal to the cylinder head, and a 12 volt negative earth supply. The cost is approximately the same as a single rolling-road session.

It must be emphasised that in cars with two or more carburettors this modern technology does not remove the need to prepare the carburettors properly, balance the air flow through the carburettors and equalize the jet heights, otherwise a one rich/one-weak situation may be disguised by a perfect overall air/fuel ratio. It is then a simple matter to fine-tune the carburettors according to the displayed air/fuel ratio, by raising or lowering the jets by equal amounts.

Permanently fitting a wide-band lambda sensor has the advantage of providing a real-time indication of mixture strength under all driving conditions. In everyday driving it is reassuring to be able to see that at no time does the mixture become too weak or too rich. In theory the optimum air/fuel ratio is 14:7 (stoichiometric mixture) but in my experience a ratio of between 11.5 and 13.0 is optimal for our cars*. This relatively rich mixture reduces combustion chamber temperature and the likelihood of pre-ignition. Cruising with only a touch of throttle tends to weaken the mixture as the partially-closed butterflies shield the jets against gas pulsations emanating from the engine that would otherwise benefit fuel vaporization[2]. In the Manchester experiments[4], for a given carburettor piston height, half throttle tests gave a weaker mixture than full throttle tests. In addition, low engine speeds tended to exacerbate "cyclic variability" resulting in a greater proportion of slow combustion cycles, leading to high combustion chamber and exhaust valve temperatures[4]. These experiments confirm that the best way to drive our cars is to keep your foot down and the revs up!

Figure 8. Air/Fuel gauge mounted above the Rapier* dashboard.

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