Air/Fuel Ratio gauge and Mr Royce's carburettor

The Royce carburettor as fitted in various forms in RR cars up till the mid 30's looks complicated with many linkages and adjustments. I have only just tackled this on my Twenty as I had thought it was running well. However after a spot of bother with fuel vaporization, due to heat soak, on stopping to help another car on a very hot day, (I should have opened the bonnet!) and a suspicion that it was running a bit weak at its 50mph cruising speed, I decided to investigate.
It is basically a twin choke carburettor with a secondary starting carburettor.
The slow running choke tube or venturi has a fixed jet within which is an adjustable tapered needle whose position is controlled by the mixture lever on the dashboard. This turns a nut screwed onto the needle to move it in or out of the jet a miniscule amount to vary the mixture. The slow running jet operates, confusingly, at all speeds, either alone or in concert with the high speed jet.
The main venturi and "high speed jet" has a similar adjustable needle to vary the mixture, and a vaguely SU-like dashpot, which is used to blank off the high speed choke at low revs, and progressively to admit more air to the engine as speed increases to compensate for the tendency, (common to all jet/venturi arrangements) for the mixture to become too rich at high rates of air flow past the jet. The high speed jet does more of the work as revs and/or throttle opening increase, at speeds of more than 4mph in top gear (it says in the instruction book!).
So you see there are really two carburettors in one, or three if you count the starting carburettor. The problem is that, although the low and high speed jets needles are adjustable individually on the carburettor, the dashboard quadrant lever works both needles to give an overall weaker or stronger mixture, so the balance between the two has to be rather carefully set. The instruction book ominously warns not to mess with the settings, but after 90 years, sure enough, they will have been messed! The instructions for resetting them depend on a very subjective assessment of what is going on due to the interaction of the two jets so I thought there has to be a better way. There is, a lambda sensor fitted to the exhaust pipe, and an air/fuel ratio (AFR) gauge, which displays the air to fuel ratio as the car is driven. You can, of course, play around on a rolling road with a lambda probe pushed into the tailpipe but I did not find that much help for setting the separate jets.
So I splashed out and bought a gauge and sensor, (not cheap) and very soon was able to see that the slow running jet was too rich, and as I had suspected, the main jet too weak. The gauge shows the air to fuel ratio on a digital display, although there is also an analogue display using LED lights which move around the dial in needle fashion. For petrol the AFR should be 14.7 to 1, to give a

stoichiometric burn (when the amount of air supplied is just that which is needed to burn all the fuel). For ethanol, the ratio would be 9 to 1 (a lower number means richer, and ethanol needs less air as it already contains some oxygen - which annoyingly we now have to buy rather than get free from the air!). In the case of unleaded petrol with 5% ethanol, I assume that the AFR for the brew would be about 14 to 1. In practice a somewhat richer mix than the stoichiometric ratio is used, giving a bit more power so I am aiming to get about 13.5 to one for normal running.

On the road the AFR gauge fluctuates depending on speed and throttle but the reading is acceptably steady and the response rapid enough so I can see a momentary richening when accelerating and a drop to a very weak mixture when rolling downhill with the throttle closed.

The method of setting of the jet needles is just as the RR instruction book says, except that I can now see rather than more or less guess when the mixture is correct. The instruction book suggests that the setting is right when the engine works properly with the dashboard mixture control midway, that it splutters or dies on full weak and emits black smoke on full rich. It is hardly surprising that RR recommended returning the car to them to do these adjustments. I found that the amount of adjustment needed to make a significant change to the AFR is very slight, as little as 1/8 turn of the adjusting nut.

I have only just got the gauge working, so it is too early to report fully, but the car definitely feels more lively, and the low speed tickover is reliable, and magnificently slow. RR recommend moving the mixture lever a couple of notches rich for hill work, and a couple weak for light throttle level work, and the gauge shows the effect of this very clearly.

I mounted the gauge on a bracket below the instrument panel, and used a black face to the dial so it does not look too out of place. The gauge requires an earth and a 12V supply via the ignition switch. The lambda sensor (a Bosch wide band unit) comes with a boss to weld to the exhaust pipe, with an 18mm spark plug thread to take the sensor. Not wishing to take the exhaust downpipe off, I made a saddle to which the sensor boss was brazed, drilled a 15mm clearance hole in the exhaust pipe on a convenient straight section just in front of the silencer, and clamped the saddle in place. This will let me move the AFR gauge easily to another car, simply needing an appropriate size saddle for the exhaust. The gauge is supplied with about 2.5 metres of cable which cannot be shortened so the excess had to be coiled and clipped under the floor.

Altogether it has been a very worthwhile project - who knows, better economy may even pay for the kit. I will report back later as I get more experience with it.

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