REPLACING LUCAS PETROL INJECTION PUMPS WITH AXIAL FLOW (BOSCH TYPE) FUEL PUMPS and METERING UNIT TUNING NOTES

For many year owners of cars using the Lucas Petrol Injection system have been encountering fuel delivery problems, particularly during hot weather whilst using the original Lucas pump[1], and when a replacement axial flow pump is fitted, without due consideration for the pumps' requirements. Whilst there are many manufacturers of axial flow high pressure fuel delivery pumps all around the world as most cars these days have electronic fuel injection, they tend to be generically referred to as 'Bosch' pumps. These axial flow pumps, as the name suggests, do not have a separate motor and pump as the Lucas unit does, but rather the motor and pump are all housed in one aluminium tube with the fuel passing over the motor, cooling it as it goes.

Invariably a poor running problem lies with the fuel pump itself. Most Lucas units have now been reconditioned at least once in their lives and are in less than perfect condition. The composition of unleaded, and now E10 fuel increases the chance of cavitations occurring where fuel in the overheating pump turns to a vapor, in which the pump spins uselessly. The fuel flow is cut, and the engine is abruptly stopped.

At RevingtonTR in the early days of these problems (early 80's) we tried a few solutions on the Lucas P.I. equipped TR5 and 6, including square-section cooling coils for the Lucas pump motor and Bosch fuel pump kits from other suppliers. The pumps in these kits did not last well, were also prone to cavitations, and caused resonance in the fuel lines. There were, even then, over 300 different Bosch fuel pumps. It is crucially important that the correct unit is used and that it is mounted below the tank and does not have to suck though the original C.A.V. filter or any other inappropriate filter. As fuel Injected Mercedes or BMWs were not commonly seen stranded by the roadside with overheated axial flow pumps during the summer months, we realised there must be an effective solution.

First, it is necessary to understand the design/installation criteria for the axial flow pump. The pump cannot draw fuel up from a lower level (unlike the Lucas unit). It requires a flood feed, draws more current than the Lucas unit and normally has the paper (micron) filter after the pump.

When arranged correctly, an axial flow pump will work well under all conditions and last longer than either a Lucas pump or an ill-conceived axial flow kit. We have now sold many, many hundreds of these kits and when all criteria are met, the system will neither over-heat nor cavitate even when exposed to extremely high ambient temperature.

Investigations of the various parts of the Lucas system, which will remain when an axial flow pump kit is fitted, reveal that there are limitations. The axial flow pump requires a minimum of 2.6 litres per minute (LPM) free feed of fuel and preferably 5 LPM. When we took the fuel delivery pipe out of a TR5/6 fuel tank and allowed petrol to flow freely, with half a tank of fuel, we got 2.5 LPM. Not quite enough, but the best we could hope for without altering the fuel tank. When the 5/16" fuel

delivery pipe was refitted [with 1/4" internal diameter (1/D)] the flow was immediately reduced to 1.7 LPM. When the Lucas filter and housing assembly was re-introduced into the line, this figure further reduced to 1.0 LPM. Clearly an inadequate feed. Add to this the normal practice of mounting the axial pump on the boot floor adjacent to where the Lucas pump was fitted (where it would be required to suck fuel up on a low tank of fuel which it is not designed to do), it becomes obvious why early pump conversion kits had a less than glittering reputation.

At RevingtonTR, armed with the basic criteria, we designed a system in conjunction with the technical team at Bosch UK, which allowed their pump to work in its intended environment. Firstly, the pump must be sited as low as possible. With the Lucas filter assembly removed, the forward LH corner of the spare wheel pan is ideal in temperatures encountered in England. In much hotter environments, the pump can be sited outside of the spare wheel compartment, a position that has proved most popular as all the smelly bits are outside of the boot and additional space in the boot/spare wheel area is freed up. We now only sell 'outside' kits as this seems to reflect customer preference. We have many units in operation around the world where temperatures are exceptionally high without problems and have campaigned our TR5 in stage rallies and races around the world in hot climates without issue. Most recently an 11,000km trip to Greece and back without trouble.

With over 30 years' experience fitting our pump kit, we know that the feed from the standard tank outlet without alteration is adequate for correct pump operation. Between the tank and the pump, we use an adapter screwed into the tank bored out to the same size as the hole in the tank outlet to maximize flow, stainless steel braided hose with large 3/8" bore and a simple in line gauze filter or motorsport gauze filter depending on the kit chosen. A stainless-steel braided hose with banjo unions connects the pump to a high-pressure filter, via a non-return valve. The outlet of the filter is fitted with an adaptor to which the original hose to the pressure relief valve is connected or our special hose RTR4048 can be used. See our website for up-to-date recommendations listed for the pump kits we offer.

The pump and pressurised filter assembly is held in a special bracket and secured to the sidewall of the spare wheel tray with shock absorbing mountings. A tap is provided to assist with filter cleaning/changing. Our most popular kit places the kit externally under the boot floor, to reduce the possibility of fuel vapour contamination in the boot. This kit is part no. RTR4050XK which includes a motorsport grade.

Installed in this way, with a correctly specified pump (we have seen some installations using a pump designed for 40PSI operation and pumps which are designed to be force fed with a fuel tank internally mounted primary pump) designed for 110-PSI (7.5 bar) operation, the pump should not cavitate and should assume a normal working life. When our kit was originally devised, we used the Bosch pump with the highest pressure output available which was just adequate for our needs. Because of this we assumed the life of the pump would be slightly lower than on modern

applications, this proved not to be the case with many hundreds of kits sold and working well into old age.

With development and improvement very much the RevingtonTR ethos, the pumps used in our current kits are of motorsport origin capable of operating at 10 bar giving a significant margin above the operating pressure required.

When considering the conversion, the following should be noted:

1. TR5's and early TR6's pre 1973 do not have an anti-surge reservoir in the bottom of the tank, the Lucas system relied on the special fuel filter design specified by Lucas to act as a reservoir. It was inevitable that customers and local garages would use anything but the correct filter (a normal CAV filter as found on a diesel engine is not designed to be a reservoir) resulting in total lack of power on left hand turns with low fuel, as all the fuel disappears off to the right hand side of the tank by centrifugal force, exposing the fuel outlet, result, no fuel to the engine. Triumph would have been inundated with complaints that were not really their fault so added an anti-surge pot inside the tank to finally eradicate the problem. If an axial flow pump kit is fitted to a car with no reservoir, these cars will cough and die on sharp corners (particularly left hand) with a low tank of fuel. The solution is a new aluminium tank with the correct internals. See below.

2. The tank you use must not be internally rusty or dirty. Remember that the pump cannot suck through a fine micron paper filter and large particles of rust will quickly block the gauze filter. The small gauze filter between the tank and the pump lives inside a glass or aluminum tube and is intended only as an indicator. Any debris found in this filter should be taken as an indication that the tank or fuel supply is suspect.

3. Early cars without a reservoir in the patrol tank had the pressure relief valve excess fuel line plumbed into the CAV filter to keep it topped up. As the CAV filter cannot be used with an axial flow pump and must be removed, this fuel line must vent into the petrol tank reservoir via an internal tube. This can be seen by viewing our aluminium tank 312359XALK on our website where there is an image with the side of the tank removed to show the internal construction. The spill return from the metering unit usually connects to a separate inlet on the top of the tank, but if only one port exists, the spill return from the metering unit can be connected to the PRV return via a 'T' piece.

4. The Lucas pump takes 3.5 amps and the standard car is wired accordingly. An axial flow pump draws 9-13 amps and will therefore require a separate feed and relay. The pump will not deliver full flow below 10 volts therefore operating battery voltage must not be less than 11.5 volts. A relay kit must be used to provide a proper electrical supply, and the alternator must be adequate. We recommend a 70amp alternator.

5. All our kits include a tap fitted between the tank and the gauze filter to facilitate ease of filter cleaning/changing. This tap when open must not introduce a smaller bore than the tank outlet. A suitable tap is included in our kits.

Tuning

1. When all the above has been taken care of, the car has every possibility of running correctly. However very few TR5-6 are completely standard and operate in the same environmental conditions as when the cars were new. If nothing else, the fuel used today is vastly different to that of the late 60's early 70's and most cars have had an engine rebuild, perhaps a different exhaust for example, which to some extent makes each car individual. It is therefore important that the metering unit is set up correctly for its individual engine installation. The engine can be considered to include all parts from the fuel filler to the exhaust tail pipe. Any changes will affect the correct running of the engine.

2. Correct running should not be considered a 'nice to have', it is essential. Obvious advantages are smoother running, better power, better torque and better fuel usage. But there are other less obvious consequences of NOT having the car in the correct state of tune. If the engine runs too lean (not enough fuel) the valves may burn out and holes can be burnt in the tops of pistons. The engine will run hot. If the mixture is too rich (too much fuel) the engine will run well, whilst using too much fuel, but will inevitably wash the bores with the excess fuel, washing away the lubrication, resulting in excessive bore wear.

3. At RevingtonTR we are in a unique position to ensure tuning work is carried out correctly and precisely. Three elements are needed

    i. A rolling road to enable the car to be run under load in the workshop and a gas analyser to measure and display the completeness of combustion from the exhaust emissions. We have an 800hp rolling road and a range of gas analyzers.

    ii. Some means of knowing what the metering unit is doing and how to adjust it for correct metering. We have a computer modeling program (see figure1) that enables us to feed in all variables measured from the metering unit, spring rates, stop positions, and cam angles. The model can then determine what fuel will be delivered for a given vacuum. From this we can adjust the Metering Unit for correct operation.

    iii. The final element is experience. Rolling road equipment and information gained is of little use if the results are not understood. Fortunately, our workshop technicians have over 40 years' experience between them ensuring the information gained can be used to adjust the metering unit to give best results for power and economy on an individual vehicle basis.

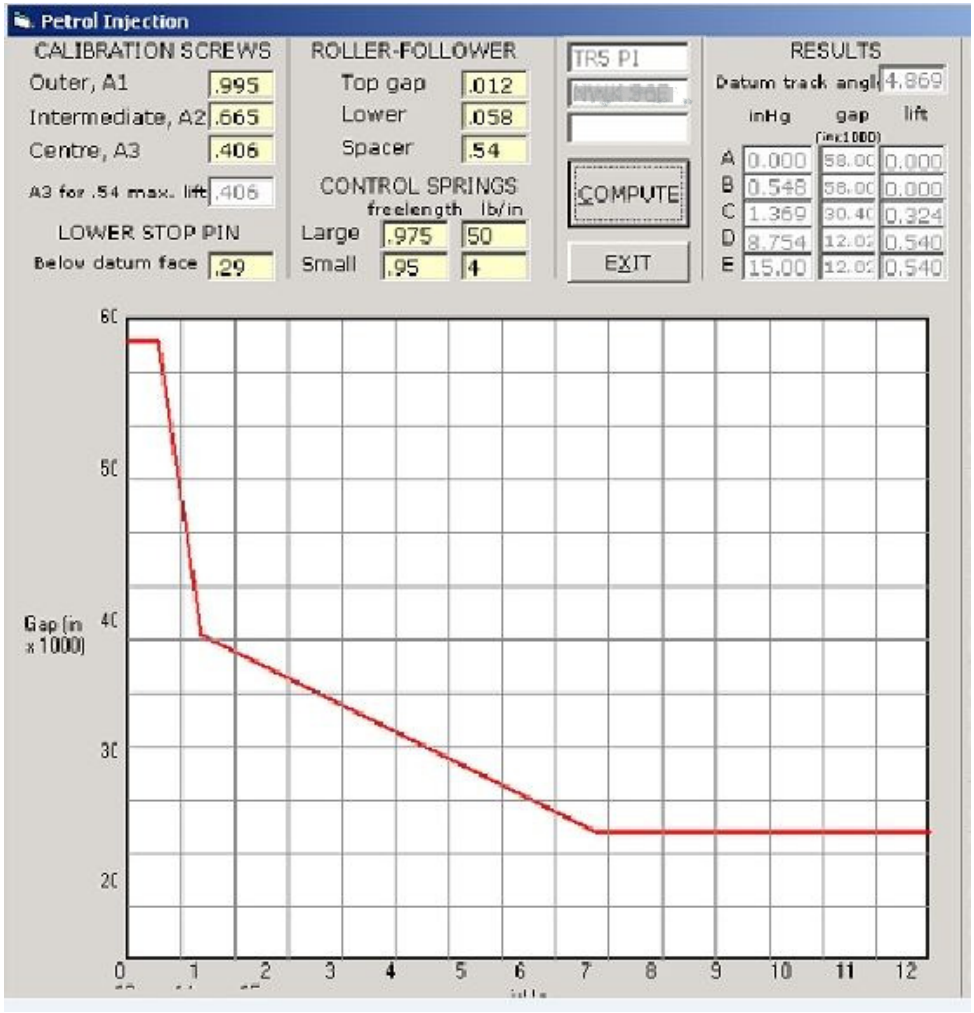

Figure 1 Screen shot of typical Metering Unit fuelling graph

We appreciate this is not of much use if you live in Australia or New Zealand, but our customers bring cars to us for this service from all over continental Europe. Once done it should not need doing again, the improvement in driving experience should prove to be well worth the effort.

Parts you might need

All parts are available from RevingtonTR: -

Fuel pump kit, internally mounted,	part number	RTR4050K
Fuel pump kit, externally mounted, SS braided rubber hoses	part number	RTR4050XK
Fuel pump kit, externally mounted, SS braided Teflon hoses	part number	RTR4050-1K
Auxiliary Fuse Box kit	part number	RTR8270K
Relay kit	part number	RTR4017K
Inertia Switch kit	part number	RTR8346K
Aluminum petrol tank	part number	312359XALK
Hose filter to PRV (longer, for original PRV)	part number	RTR4048
Hose filter to PRV (Standard type Teflon, for original PRV)	part number	215642SS
Aluminium shield	part number	RTR7259
New style diaphragm PRV	part number	RTR4456K
Alternator kit 70amp	part number	RTR8124K

Note [1] The motor used as part of the original Lucas high pressure fuel pump is a windscreen wiper motor modified to take the extra load of moving significant quantities of fuel at high pressure. This extra load requires extra current draw which in turn creates heat. This heat is passed to the gear pump and ultimately to the fuel in the pump which when hot enough will cavitate resulting in no fuel delivery. This was a problem from day one as Lucas engineers who worked on the issue and subsequently became TR owners, having inside information, will testify. One engineer came up with the idea of wrapping a coil of pipe around the pump and feeding the return from the PRV to the tank via this coil. In the early 80's RevingtonTR took this idea one step further by utilising a square section coil to maximise the contact area with the motor body. The improvements were limited and still pumps failed. As pumps got older failures increased and a permanent solution was required.

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