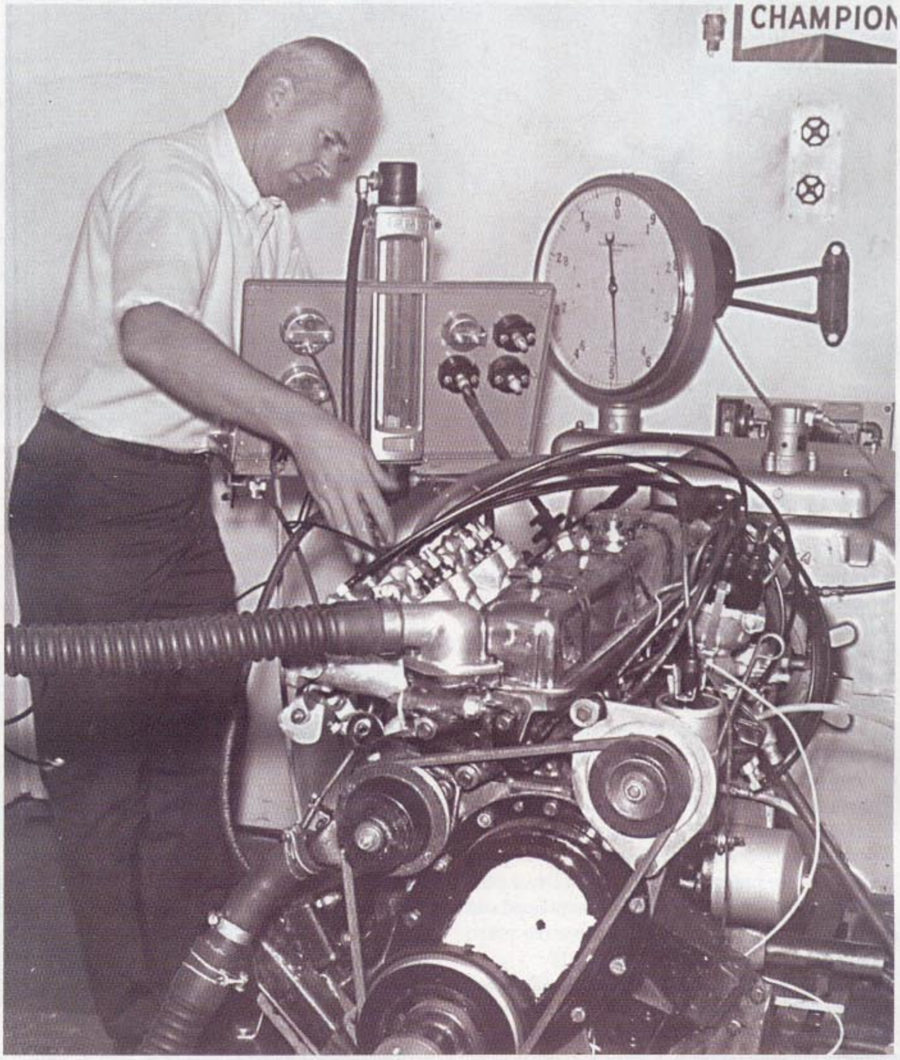
P.I. PERFORMANCE

The Lucas fuel-injection system, as originally fitted to six-cylinder Triumphs, has long been the source of frustration for many enthusiasts. Here, in an exclusive article, legendary engine tuner and ex-US Triumph Competition Director, Kas Kastner, reveals for the very first time how he overcame problems associated with using the P.I. set-up in competition.



Above: *R.W. 'Kas' Kastner experimenting with a TR250 engine on the dynamometer in 1968 at the workshops of the US Triumph Competition Department in Gardena, California*

The TR5 and other six-cylinder Triumph models in the UK were delivered with Lucas fuel injection (called P.I. for Petrol Injection). In the USA, the TR250 and TR6 came with twin Stromberg carburettors. The difference was an astounding 45–50bhp.

Due to this lack of power, and the way the cars were classified by the Sports Car Club of America (SCCA), I arranged for the US Competition Department to buy several sets of the Lucas P.I. system. The units we obtained were the same as those used in Europe and other countries outside North America. Then our problems began.

The standard system is great and works just fine on the street but, for racing purposes, a much better control of the fuel was needed. In stock form, the system is controlled by a vacuum signal from the inlet manifold and the control unit is mounted to the rear of the Lucas fuel distributor. This is okay, normally, because the standard engine has a mild cam and produces a nice vacuum signal. The problems arise when fitting a big overlap camshaft and the vacuum signal is reduced to almost nothing. With partial throttle opening, the vacuum drops to zero, and thus the fuel system goes onto 'full rich', regardless of the intermediate throttle positions. This explanation isn't exactly correct but, for the purposes of getting to the modification story, this description will have to do.

First off, it was learnt that Lucas had a competition-type injection system. Fitting this amounted to removing the vacuum contraption on the back of the fuel distributor and replacing it with a little aluminium casting which houses a small cam and is connected to the throttle linkage. The cam regulates the length of the stroke of the fuel distributor shuttle and, therefore, you have a known amount of fuel for the various positions of this cam. Perfect? Well, not exactly – better, perhaps, but not quite good enough.

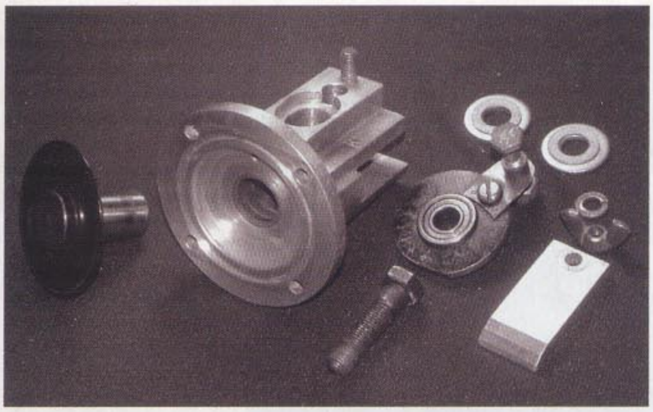
We obtained one of these competition systems and made the change over. Right off, we had better power and a much greater degree of control. The mixture could then be enriched or leaned-out slightly by using the small detent adjustment incorporated in the design (a change of only 0.001 inch makes quite a difference in the fuel delivery). Major mixture adjustment was made by removing the casting and cam, then adding or taking away special square shims (of varying thickness) between the distributor housing and the aluminium casting. Sounds good, huh?

This idea has been used in dozens of racing cars over history, including my old McLaren M20 CanAm car, the Lola Formula 5000 cars and a multitude of other sports racing cars. However, these were all full-on race cars with close-ratio gearboxes. When adding the competition P.I. to a modified production engine with a limited rev range that is using a standard four-speed gearbox, it was discovered that the fuel could not be regulated in the small increments needed to give the maximum benefits in power or tractability.

After a few races using this system, a problem developed with wear in the bushes which kept the cam in place in the aluminium housing. The cam had two bushes of a bronze material, one on the top, another on the bottom. The inside diameter of the bushes was wearing on the shaft, while the outer diameter was wearing on the bore of the cam. As a consequence of all this wear, the cam adjustment for mixture might actually go lean when you tried to richen it just slightly with the detent mechanism provided. This is probably not too critical on a big V8 engine which makes over 600bhp but, when dealing with a third of that output, every little bit makes a difference. And the whinging of the driver tells you when it isn't correct!

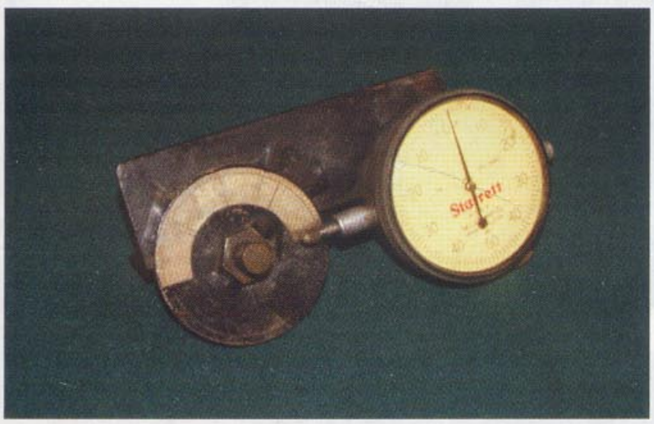
The issue I found was that the Lucas cam was just too small in diameter to allow the considerably more throttle position fuel changes needed than with a full-race engine. Additionally, the wear in the bushes could not be allowed for with any sort of reliability.

Production car races in those days generally had short practice sessions, and it was essential to have a method of adjusting the mixture quickly during those sessions. Taking the unit apart to change the shims was a real pain, and very time consuming. I needed a system that would enable fast, accurate and positive mixture change control which eliminated the wear factor. I also needed a



Left: *Disassembled cam-operated control unit shows all the new parts made and developed by Kas Kastner for competition use*

Right: *This is the original shim box used by Kas in 1968. It contains a selection of different thickness shims – simply made by cutting the tips off feeler gauges*



Left: *Dial indicator jig used for checking larger cam against test measurements obtained on dyno*

larger cam diameter to give more area to cover the various intermediate throttle positions.

I came up with a scheme that did all of those things – and did them very well. What it amounted to was machining a new housing to be attached to the rear of the fuel distributor that held a larger cam and had an opening at the top with a cover secured by a wing nut. Through this opening, the shims could be slipped into position between the cam face and the diaphragm barrel. This arrangement allowed adjustments to be made without even turning off the engine, so quick changes during practice were a breeze and ensured the engine was in the best state of tune, regardless of the climatic conditions.

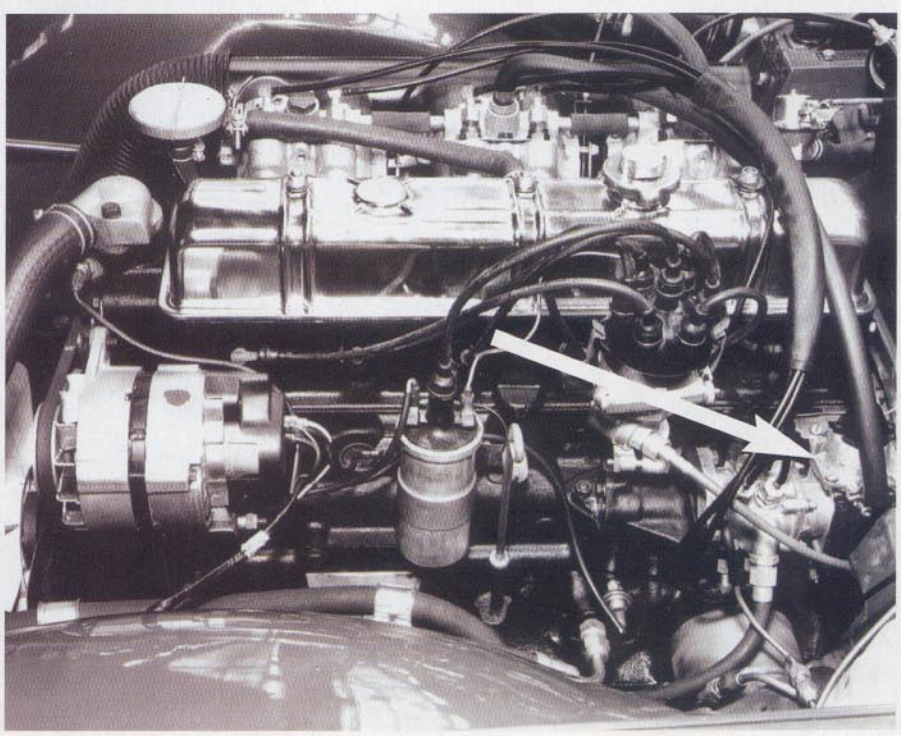
As part of the shim pack, there was a standard shim which also served as the richening device for cold starts. That shim was used in tandem with others to get the optimum setting. When changing shims with the engine running, you just pulled out the adjustment shim and the engine went to a rich condition for a couple of seconds, then immediately back to the setting you wanted very accurately when another shim was inserted. This worked wonderfully well.

Another thing that greatly improved the accuracy of the mixture was replacing the bronze bushes with sealed ball bearings.

The connecting tab on the cam for the throttle linkage is replaceable, so that a shorter or longer arm could be fitted, if needed. The tab is held in place with a slot-headed screw and two dowel pins for positive location. The major positions on the cam are indicated by centre punch marks and, with a highly visible tiny hole drilled for the idle position, you could look down through the shim-inserting opening and check that the idle position was lined up exactly with the centre of the diaphragm barrel. You could also richen or lean-out the idle by changing the length of the connecting link to the throttle assembly. All in all, it gave us quite a comprehensive and very accurate means of adjustment for the entire scale of the metering unit.

The cam profile was worked out on the engine dynamometer using a depth micrometer attached to the shuttle end of the fuel distributor unit. After measuring the depth for various throttle openings, mixture and load demands, I then transferred that information to the new cam

Right: *Production six-cylinder Triumph engine with Lucas P.I. system. Arrow points to the standard vacuum control unit*



Below: *Larger-diameter cam made by Kas with sealed ball bearing in centre. The tab for connecting to the throttle linkage is quickly detachable for easy adjustment*

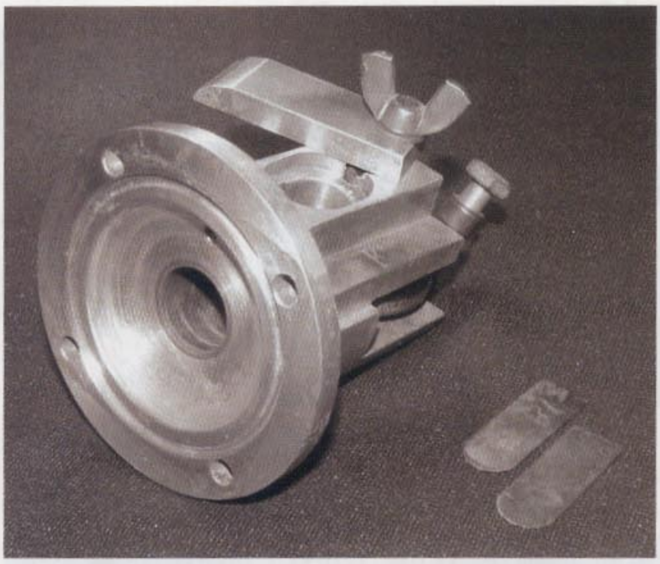
blank. For this I used a jig made by attaching a dial indicator fixed to a steel plate, with a mounting stud for the cam positioned alongside.

If you wanted to build a similar type of unit, but don't have access to an engine dyno to gather the required data, I would suggest you copy the standard Lucas competition cam and just enlarge it to fit the bigger diameter of the new blank. My cam blank was 2.00 inches in diameter, 0.125 (1/8) inch thick and made from a heavy washer bought at a local hardware store. Once profiled, it was then hardened by heating it, then dropping it into a small pot of clean engine oil – simple and effective!

With the mixture under control, I then went on to testing various inlet systems to try and gain some more power. The torque was greatly improved on the six-cylinder engine by making the velocity stacks longer using rubber hose and Weber carburettor trumpets. Eventually, the longer length we needed would not fit inside the inner wing, so I made up bends out of radiator hose, and this 'swept-back' design allowed us to get the dimension that had proved to be the best.

Actually, an even longer tract was rather better than the 'swept-back' arrangement, but I could not find a way of keeping it all inside the engine compartment. My next plan had been to make up some tight bends out of aluminium tubing, which would extend the inlet tracts back over the top of the rocker cover to the distributor side of the engine. Unfortunately, other things came along and the project was never completed.

Along the way I did make another power increase, by moving the injectors out as far as possible in the velocity stack. This improved both the torque and the horsepower. I no longer have any photos of that modification, but it is easy to do and can be tested by just slitting the rubber hose with a knife and stuffing the injector in position. Obviously, you must plug the original injector holes in the manifold (either additional injectors or a pipe plug will do). When testing this way, be sure to tape the fuel lines and injectors securely in place – so that they don't come flying out during a run and burn your car to

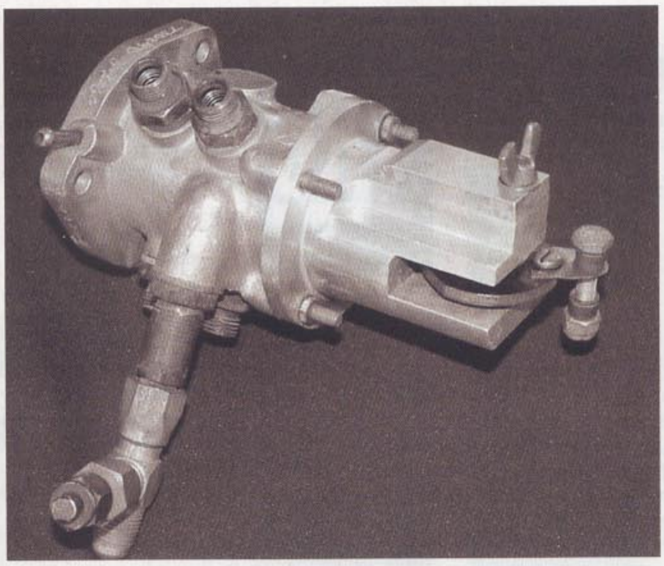


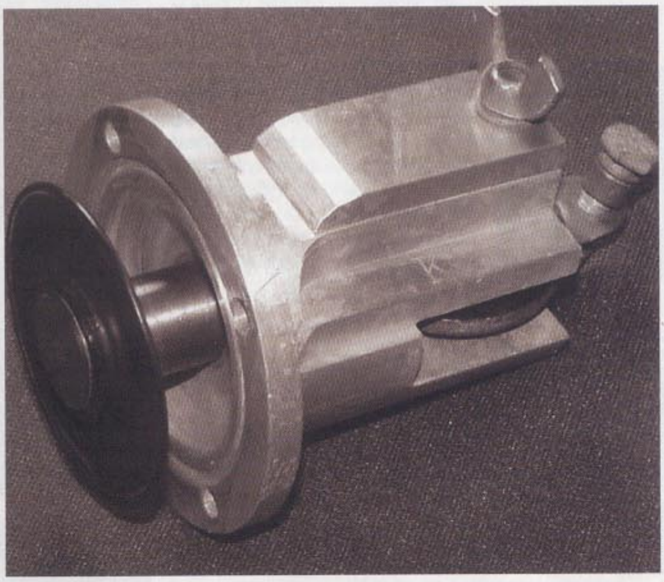
Left: *Kastner control unit (minus diaphragm and barrel), showing aperture for inserting shims at top with cover open*

Right: *Using radiator hose for bends, Kas created this 'swept-back' arrangement to enable an extended inlet tract to be fitted without interfering with bodywork. His ultimate aim was to make up an even longer design, but this idea was shelved*

Left: *Driver Jim Dittemore discussing the performance of his fuel-injected TR6 with Kas during a test day at Willow Springs, California, in 1970*

Right: *Lucas fuel distribution unit with Kastner cam-operated control attached. (Shown for illustration purposes only – final assembly would require all nuts, washers, etc)*





Left: *Fully-assembled Kastner control unit with diaphragm and barrel in place and top cover closed*

the ground!

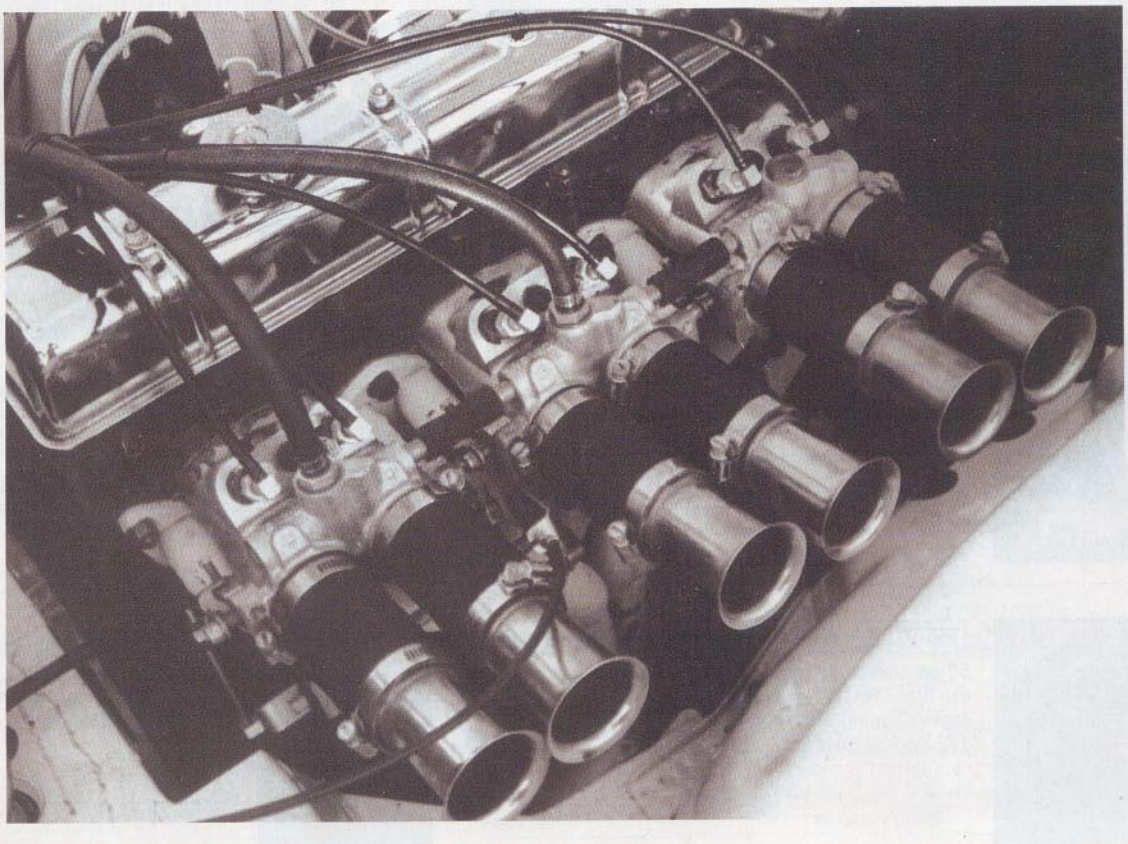
Don't worry too much about which way the injector is pointing. In testing on the dyno I found that the engine really didn't seem to care all that much about the direction of the injector – including pointing straight back towards the inlet trumpet. Weird. The power remained the same whatever the orientation of the injector; the only difference was when it was moved outboard of its standard position – and then everything was better.

To further improve the system and clean up the injector fitting, I also made up some small bullet-shaped housings and assembled the stock injector pieces into them. These were mounted in the centre of the velocity stack, pointing directly downstream towards the engine. They looked terrific – but didn't make a bit of difference against the tests with the injectors just shoved into a slit in the rubber hose and taped in place. As I said before, weird.

This is not a system that I would recommend for road use. The off-idle throttle positions are difficult enough to work out for a race car, and the standard P.I. system works very well. You might want to try the longer inlet tract, and even moving the injector outwards, because I do believe that these mods will make a nice increase in performance for a street-driven Triumph.

SPECIAL THANKS

My thanks to Greg Lund of Tempe, Arizona, USA for his assistance. Greg purchased my modified injection system from the people who had come into possession of my TR6 thirty years ago. He saved those parts for his own future plans with a TR250, and loaned them to me for photos and inspection. It was really fun to handle the items that I made so long ago – and to see that they were all in very good condition and ready to work again.



Right: *Limited clearance with inner wing restricted length of straight inlet tracts; longer velocity stacks were made from rubber hose and Weber carb trumpets. These greatly improved torque output*