

# Re-Building an R500 Engine

By Keith Jecks

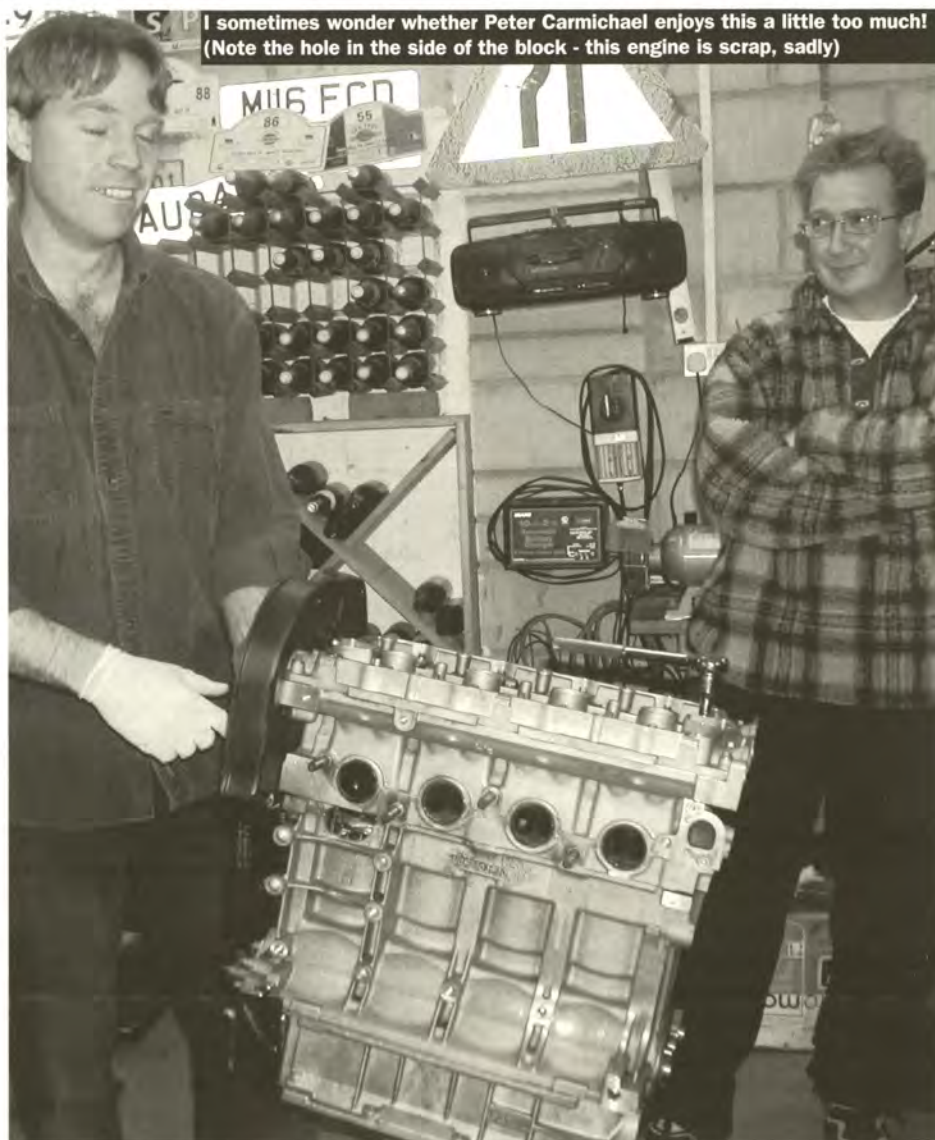
It was at Lydden last year that the BANG, followed by a great cloud of smoke convinced me that perhaps it was time that I had better get my engine looked at...Fortunately for me (but sadly not for Richard Ince) it wasn't my engine that exploded so spectacularly. I always knew that R500's used a cutting edge race engine, but I have to admit that there are some characteristics of a race engine that I would prefer not to share with F1 cars!

## The Dilemma

Caterham have always said that R500's should be 'refreshed' after 3,000 track mile intervals, or 20,000 road miles. I suspect that the former figure is firmer than the latter because it is derived from much more experience - there are not too many R500's out there with 20,000 road miles under their belts. Engine builders like Roger King will tell you that one track mile puts the same stress and wear on an engine as something like 10 road miles, so the latter figure is probably conservative for a car that never goes on the track. Richard Ince is a race driver, and drives his cars to the limit, so the fact that the engine went after over 4,000 track miles is an indication that Caterham mean it when they give a 3,000 track mile limit for the engine if used hard....

What about my engine? At that time (September last year) it still seemed to go as hard as ever, and gave me no reason to think that it needed any attention at all. When I tested them, all cylinder pressures were actually better than when the car was new, and the oil pressure was as good as it had ever been. But, it had done 6,500 miles, about 4,000 of which were on track....

When I spoke to Graham Fuller of Minister (who build all the R500 engines for Caterham) about my predicament, he was characteristically cautious in his advice. He pointed out that although the bottom end is pretty tough now that the early cars' teething troubles have been sorted out, the top end components are 'lived'. In particular, the valve springs and valves take quite a lot of punishment at 9,000 rpm (which my car is limited to, unlike the 8,600



I sometimes wonder whether Peter Carmichael enjoys this a little too much!  
(Note the hole in the side of the block - this engine is scrap, sadly)

rpm that is recommended by Caterham) and he felt it would be wise to at least take the head off and have a look.

## The Start of the Process....

Richard generously arranged for his engine to be sent to my house, so that Peter Carmichael could run a workshop showing people what is involved in a rebuild of a K-





series engine. From this, and a careful reading of the Haynes manual on the K series (I used the Land Rover Freelander book, which is excellent) I became braver, and decided that I would do the job myself, with help from the excellent engine guru Roger King, who provided me with technical support, and supplied all the parts I needed.

Now, it should be said that I am not a great engine expert, and have never rebuilt an engine before. I did build the car myself, and it seemed to me that if I did everything methodically and carefully, the work did not seem too difficult. As ex-Chairman Roger Swift kept telling me, 'it's only an engine - there is nothing particularly special about an R500'. And so it started....

The K-series engine is a quite brilliant piece of design. According to Brian Fitzsimons, who apart from being the caricature of the crazy Irishman, happens to be head of powertrains at Aston Martin (and a cross flow Seven owner to boot), the K engine represented a true step forward in the development of small production engines. It comprises five principal 'layers' of aluminium. From the top, you have the camshaft carrier that includes the oil ways to the cams. This fits to the cylinder head (the top of which carries the cam shafts and all the valve gear). Then you have the main block, the bottom of which carries the crank, and another ladder that holds the crank in place. Finally there is the bottom ladder that carries the oil ways for the crank bearings. (Incidentally, the oil distribution paths are shaped like two letter 'K's', which is apparently why the engine is known as a K series.)

All these layers are held together by ten long bolts that go all the way through the engine and keep it in shape. Once they are removed, the whole lot distorts so that you can no longer turn the crank shaft. This has caused some people to claim that these engines need stiffening if they are to be tuned, but there is now enough experience of tuned K-series to prove that this is not

correct. The cylinders themselves are steel tubes that fit precisely into the aluminium block. Once the head has been removed, great care is needed to ensure that these do not move, otherwise the engine will need to be completely stripped.

## Engine Out



Marks of the bore of cylinder 3

I had initially intended to just take the cylinder head off and replace all the valve springs, which can be carried out with the engine in the car, and is quite an easy task. Unfortunately, when I looked at the cylinder liners, they were quite badly marked (see photo). The pistons themselves also had an amazing amount of movement (0.50mm at the top of the piston) in the bores. Roger King reminded me that the engine was working just fine, and that this staining is quite normal for any engine that is not used daily, and it is nothing to worry about. He also pointed out that most novices get worried about the amount of slack in the pistons, but it is also normal. What matters is the amount of clearance when the piston is hot, of course... Having said all that,

Roger did recommend that the liners be removed and glaze busted. This is a simple and cheap process that applies a new finish to the bores. Unfortunately it meant that the engine had to come out. Which meant that I might as well have a look at the bottom end as well. Getting the engine

out is not hard, it just takes a long time if you don't do it often, and requires all the electrical connections, etc. to be tagged so that you know where they go on reassembly.

Taking the engine apart was very easy - it all comes apart logically, and there are very few special tools needed - those that are do not cost much either - the camshaft locking tool was under £5, and the clutch alignment tool £10 (required for reassembly). In addition to this, you need a crankshaft locking tool, which I made from a small piece of scrap metal that was lying around.

When I had all the parts on the workbench, what I could tell was the following:

1. Oil pumps break when you drop them.



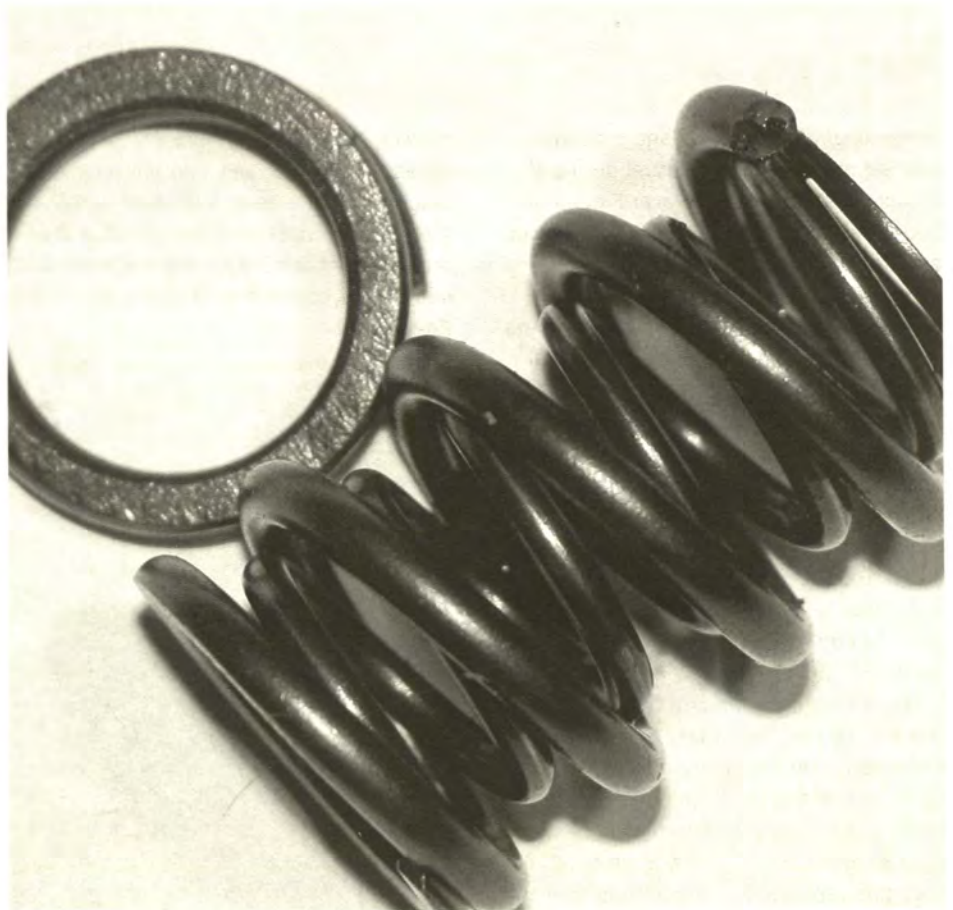
2. On a cold day, the cylinder liners are not such a tight fit, and one might drop on the floor if you are not careful.... They then need to be replaced. Bugger!

3. One of my valve springs was broken. R500's have double springs, fortunately, and it was an outer one that had broken (see photo right)

4. One of the main bearings had a few chunks out of it (see photo below), which looked worrying. I recall that when the car was new, at its first oil change, I noticed pieces of soft metal in the oil and it may be that this damage has been there from when the car was new

5. I couldn't tell about the condition of the big end bearings, but they looked a little worn to me.

6. I could do with a better work bench! So, all the parts were put in the boot of my car, and taken to see Roger King. He confirmed that all the bearings needed replacement, and suggested that valves and springs should also be replaced, and that new rings would make sense. He also recommended new water pump and cam belt tensioners, largely because they are very cheap, and the consequences of failure very expensive.







He ordered all the parts I needed (including all the gaskets that I knew I would forget until I tried putting it all back together).

The process of reassembly went amazingly smoothly, only taking about 6 or 7 hours to do. Peter Carmichael showed me how to check the valve clearances. The key trick is to remove all the cam followers apart from the one you are testing, write down the size of each shim, plus the clearance, from which you can juggle the shims around so you should only have to acquire new shims for a few cylinders. Roger King couldn't help on this one, which required some of my shims to be ground

down, but fortunately the excellent Dave Andrews came to the rescue and gave me exactly the sizes I needed.

**The Moment of Truth**

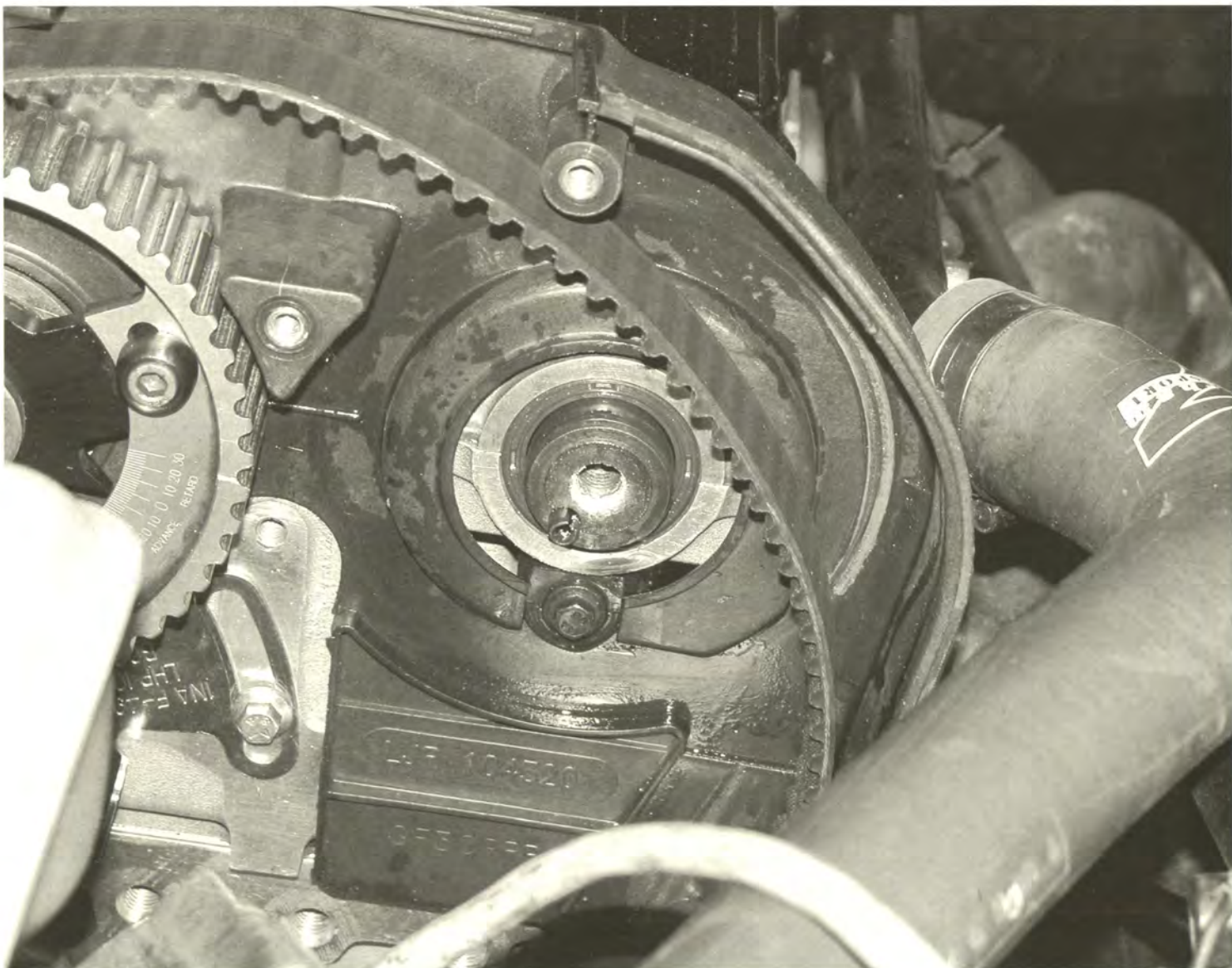
After all the spanner work, the time came to reinstall the engine in the car, using new engine mounts (the old ones turned out to have disintegrated when the engine was removed).

This was a surprisingly easy task, and in a little while the car was ready to start. I removed all the spark plugs, and pressed the started button. After an agonising wait, the oil pressure rose to the 65 psi I was hoping to see. Brilliant! Now, put the plugs

back in, press the button, and... IT WON'T START! Check all the obvious things, and discover that there was no spark coming from the coil. Hmm.

Now, with a modern engine everything is controlled by computer, and I really had no idea what to do. After mulling over the issue over-night, I decided to try my electronic bits on another car, which worked just fine, so at least I hadn't broken any of the computer bits.

When I looked at the engine, there were connectors for the feed to the coil, the crankshaft sensor, various temperature sensors, and so on. I noticed that the





crankshaft sensor plug, and that for the coil looked rather similar. I wonder.... Swap them over, press the button and BINGO! It started and made all the right noises!

**So, What was the Damage?**

The breakdown of costs was as follows:

Valves	£300
Springs	£150
Gaskets etc	£75
Glaze busting bores	£25
Piston Rings	£75
Oil pump	£95
Big end bearings	£125
Main bearings	£30
Sundry belts, gaskets etc	£200

**Total £1075**

In addition to this were items such as the engine mounts, clutch, and so on bringing the total cost of the project to about £1250. Oh yes, plus £550 for the workbench and cabinets from Halfords....

The overall cost seems pretty reasonable

to me, and gives the lie to ideas that R500's are expensive to run for what they are. Although you will hear people giving wise opinion about the costs of running these cars, for a machine that is always one of the very fastest cars on any track day, this is very inexpensive motoring for two years hard use. Next time, I will probably not replace the valves, because I am sure it was not really needed, and as long as I don't drop bits, the rebuild cost should only be £650 or so.

**So, how does it go now?**

The car has now been well run in, and it has experienced track days at Llandow and Cadwell Park. On both occasions it ran very well, delivering much more power than previously. The only problem was a slight oil leak from one of the camshafts (see photo on the previous page), which took two attempts to fix, but is now fine. Despite this, the oil consumption on these track days was markedly better than previously.

One interesting thing is that ever since the car has been new, when I came in from a track session, the datalogging that comes standard with the R500 Stack instruments showed that although the oil pressure was 55 psi or better most of the time, it had fallen at times to under 15 psi. Caterham and Minister both had a look at my car early in its life and concluded that there was nothing to worry about, which was, I am sure, true. Having said that, in the same conditions, the car now shows a minimum oil pressure of 45 - 50 psi....

So, would I recommend others to have a go at rebuilding their engines? Definitely - it is incredibly satisfying to be using an engine you built yourself, and when things go wrong, you are in a good position to know how to fix it. If you have the slightest inclination, have a go!

My thanks to Roger King, Peter Carmichael and Dave Andrews for their help. They protected me from blunders!

