WEEK ENDING JULY 15 1972 · 12½p

Motor

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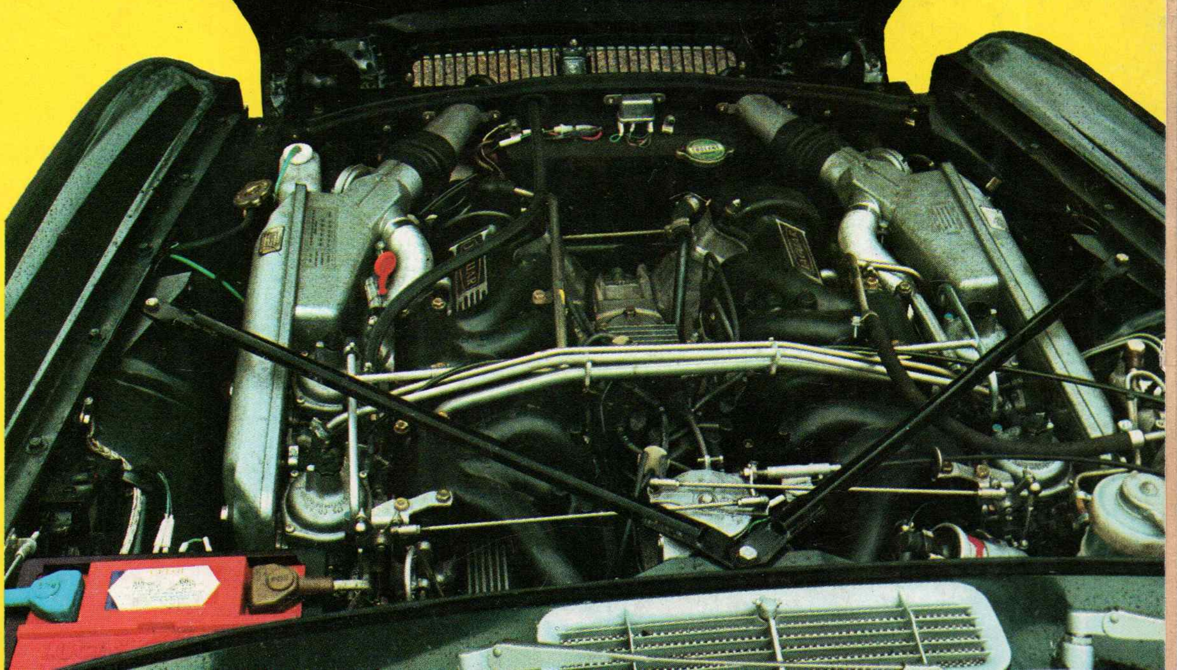
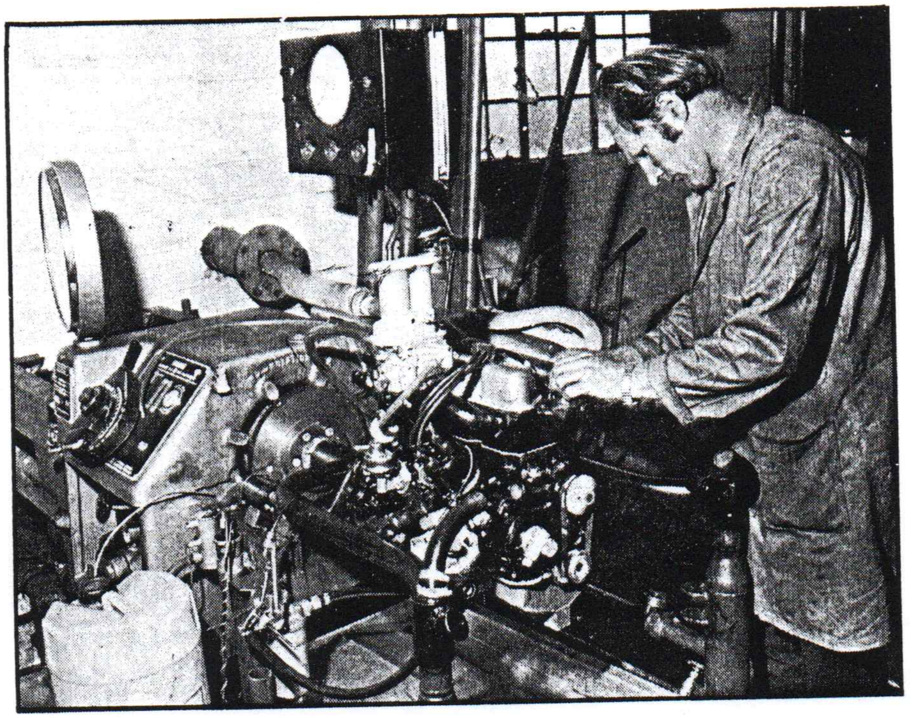
AT LAST! A V12 ENGINE FOR THE XJ JAGUAR





TITAN-IC POWER

Derek Lawrence's Titan has won all its seven races at Silverstone this year. What's the secret? We asked Titan's engine wizard Roy Thomas to explain. His frank and revealing "exposé" is quite the most detailed account of what blueprinting is all about we've seen. On page 26 Motor's Gordon Bruce tries the Lawrence Titan for himself...

The object of blue-printing a production engine is to try and bring hand finishing techniques to a mass produced article. As very few items of the engine may be changed, let's deal with these first.

We have the choice of a standard V-belt drive to the water pump or a tooth-belt drive. The latter is obviously an advantage because it cannot slip under acceleration. Conversion costs about £10.

The next change is to dry sump lubrication. The cheapest method is with a side-mounted oil pump, a remote oil filter, and returning the oil to the drilled and tapped block. Or you can use a side mounted oil pump which has a re-entry into the pressure pump body doing away with the need for machining the block. Thirdly, there's a front mounted oil pump (the most expensive) which takes its drive from a key and Oldham coupling inset in the nose of the camshaft. It also makes the engine longer and is therefore more difficult to fit into the chassis. The only set-back with the side mounted oil pump is that you put almost twice the load through the spur gear than was originally intended. However, provided the pump is manufactured to fine limits, these spur gears should not give trouble, witness their use in FVA/FVC engines.

We are also allowed to modify the oil pan for dry sump lubrication. Whilst this appears to be a simple welding job, unless you have considerable expertise in the welding of structures which have been deep drawn, it is best left to experts. An exchange pan can be purchased for about £12 including a filtered pick-up.

The remaining item that we are allowed to modify is the rocker cover. This simply needs blanking where the oil is normally applied and a tube welded in to provide breathing. Make sure that the tube welded in for breathing is not in line with oil pressure areas.

Now to the improvements. First, make sure that all items are down to the minimum weight allowed. Some of the parts are grossly overweight and this all absorbs power; the lighter it is the more free revving the engine will be.

Before balancing the crankshaft it will need de-burring all over including and especially inside the oil drilling. This can be done with a small broddling stick. The crank can also be brought down to weight while being balanced.

The flywheel and clutch should be balanced separately, removing the excess weight from the periphery of the flywheel. This should then be assembled to the crank and the whole unit balanced again.

Now the block. All machining operations must be completed first. If a side-mounted oil pump is used, a tachometer drive is needed, normally taken from the front of the camshaft, through the timing cover. All the necessary adaptors are available and no special parts need be made. Check all the bores for roundness, taper and size. When the block is manufactured each bore is machined by a separate boring head and it is not unusual to find a few thou variation. We generally overbore by 0.001in. and then hone. Much bigger than this and you will have blow-by problems; if it is left standard it will take ages to run-in.

As a general guide, we grind 0.006 in. from the head face of the block: firstly to ensure that this area is flat, and secondly to give approximately the allowable compression ratio. When the block has been machined and thoroughly de-burred it is most important to remove all the oil gallery bungs and thoroughly clean out the drillings. Some of the oil gallery bungs will put up quite a fight, but unless you want swarf circulating, then they must be removed. Block off the standard engine breather.

The pistons present no problem at all: they just require balancing for dead weight by drilling or machining underneath the gudgeon pin bosses. But the connecting rods are obviously quite important. They need balancing for dead weight and end for end. However, before balancing make sure that when they are torqued up the bore hole is round. We have often found the dowelling of the connecting rod cap to be ineffective, allowing the cap to move sideways which is obviously unsatisfactory. Under these circumstances it would be necessary to re-dowel. With the caps torqued into place on their respective rods, the side faces of the big-end should be lapped to a satin finish.

Now we are ready for balancing. Without expensive equipment you obviously have to send this out, but the principle is basically to bring all the small-end areas to the same weight first. Whatever your lowest small-end is, bring the other down to it and then take the remainder of the weight to be removed from the big ends. This should give us four rods of equal dead weight and equal weight end for end, but taking the majority of the weight off the big end is most important as this affects the secondary balance of the crank.

Check that the camshaft is in good condition and has no porosity marks. Check the bearings for straightline running. It is possible to straighten the camshaft but this is best left to somebody who knows what he is doing as it can be very easily broken. There is not much point in trying to check or measure the camshaft as there are very few people with the equipment to do the job accurately.

We are not allowed to profile the valves in any way so all that can be done is to cut them in by hand. The head face itself should be ground to give a flat and even compression of the gasket. When it comes to fettling out the inlet and exhaust tract it has been our experience that a beautifully polished head is not usually as good as one that has been roughly finished. We grind away the walls and then finish with rough emery. Most of the valve guide protrusion can be ground away without any detrimental effect, but don't spend hours and hours grinding away; it just isn't worth it. We find also that the spring platform area tends to vary somewhat. We have found Terry's extra strong valve springs for this model are quite suitable; they can be shimmed up to give a fitted length of 1.25in. This will enable you to rev quite easily to 7000 rpm.

Now you can begin to assemble the engine. Assuming that everything is spotlessly clean, start with the main bearing shells. We use Vandervell competition bearings which have a little extra running clearance. Oil the bearings generously before fitting to the crankshaft, pull the main caps down evenly and torque to 60 lb. ft. The crankshaft should spin freely and should have an end float of up to 0.012in. If it does not spin freely then disassemble and rectify the cause of the tightness. The rear crank seal and then the flywheel can then be fitted.

The next job is to fit the cam followers with a liberal coating of oil on the shank and a spray of anti-scuffing compound on the tappet face. Next the pistons and connecting rods can be installed, again with a liberal coating of oil on the big-end journals. The big-end torque is 32 lb. ft. There are no locking devices required on the big-end bolts. You should ensure that the big-ends have at least 0.005in. side clearance. Be sure that the pistons are in the right way round and the gudgeon pin circlips are firmly secured. The camshaft can be slid into position but first spray all the cam lobes with anti-scuffing compound. Make sure the cam turns freely in its bearings; it seldom does and reqires a lot of fitting. The cam thrust plate can be fitted and locked.

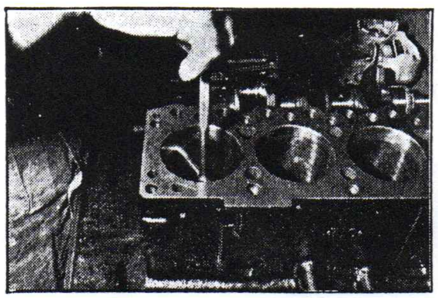
Now establish the cam timing. Firstly install the sprockets and timing chain with a straight dowel in the camshaft and the two marks on the teeth lining up. Also install the timing chain tensioner. This gives the standard production set-up; but we want better than this and to get it you need a degree wheel and a dial indicator. Secure the degree wheel to the flywheel and make yourself a pointer to secure onto the back of the block. Firstly establish the top dead centre (TDC) of No. 1 piston. With the dial indicator set above the piston, preferably in the centre of the piston, bring the piston up to TDC until the dial indicator shows maximum height. Now set your degree wheel on the flywheel to zero on your pointer. To be even more accurate than this, turn the flywheel one way until the piston moves down the bore 0.050in. on the indicator. Read off the degree wheel — it should show you something in the region of 13°. Now go back to TDC again, and turning the engine in the opposite direction, read 0.050in. down the bore again. Once again you should be in the region of 13° but it is more likely that you would have read 11° one way and 15° the other. Correct the degree wheel to give you an equal spread. Now you have obtained a true TDC. Make sure the degree wheel is now locked up and cannot move.

Now give the camshaft the same treatment. Install a push-rod on No. 1 cam and your dial indicator above the push rod. Turn the engine in the direction of normal rotation until the dial indicator shows maximum lift. Read off the degree wheel and make a note. Now turn the engine by the flywheel in a clockwise direction until the dial indicator drops 0.010in. Read off your degree wheel and it should give you a reading of about 22° past your maximum lift reading. Now turn the engine the other way going past the 0.010in. position and coming back up to it again thereby taking up the slack in the timing chain. Read off the degree wheel again and you will know from these two readings how far your cam timing is out on that particular cylinder. Repeat this process on all cam lobes logging the results as you go.

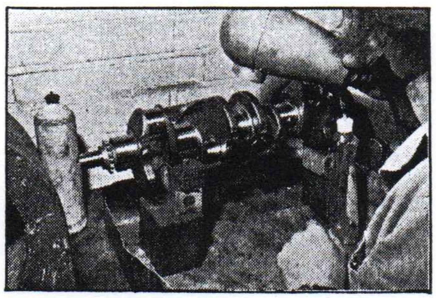
It is quite normal to experience several degrees variation from cylinder to cylinder, and remember that they are crankshaft degrees and not camshaft degrees. The designed timing of the cam is the inlet fully open at 109° after TDC and the exhaust fully open 109° before TDC. Having established a log you can now set about a compromise to give you the best timing overall, achieved by an offset dowel. These are available in 0.006in. increments which roughly equal 1°. When this is all done the front end can be locked up and finished.

Now the cylinder head can be fitted and torqued down to 70 lb. ft. Use the head gasket dry as this gives the best results. Before fitting the rocker assembly we have found it necessary to fit an oil restrictor in No. 1 rocker pillar. Once the engine is running over 6000 rpm there is too much oil supplied to the rockers. We fit an aluminium bung into the oil hole of No 1 rocker pillar which is then drilled out to 0.060in. Install the rocker assembly and torque down to 25/28 lb. ft. and then set the tappets. We have found the best results at 0.012in. inlet and 0.015in. exhaust, set cold.

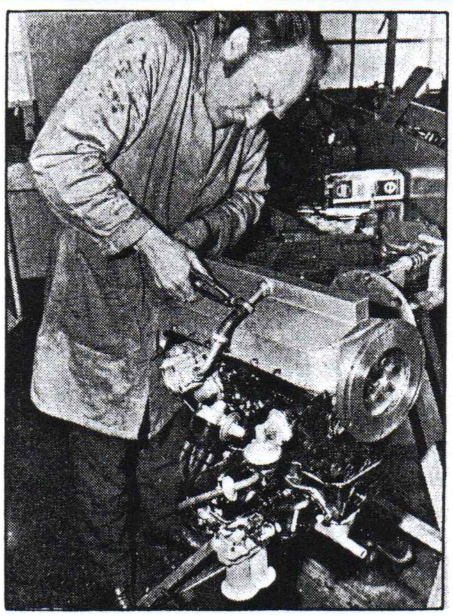
Now the fun really starts. Set up your dial indicator again on the top face of the valve spring retainer. Turn the engine over in its normal direction and measure the valve lift achieved at each and every valve. You will find quite a variation. This is due mainly to the rocker ratio which is 1.54:1 on



Above: bore measurements being taken with an inside micrometer



Above: examining the crankshaft for cracks.



Left: tightening the clip on the oil line from the dry sump. The engine is then ready for testing on dynamometer — see facing page

Below: the con rods should be balanced for equal dead weight as well as equal end to end weight

Below: checking the crankshaft journals with a micrometer

the Ford, or should be. If you find that some of the valves are way down on lift then the only alternative is to find a rocker which has the correct ratio. Remember you are strictly forbidden to alter the rockers in any way. Don't expect perfection: we carry a stock of about 2000 rockers and have one hell of a struggle to find a matched set. When you have done the best you can you are just about there.

The inlet manifold is best left alone with the exception of machining the top face horizontally. This means that the carburetter securing studs are at a slight angle, but this has no ill effect.

The next problem child is the carburetter. Most people fit a bellmouth of some description but I doubt whether this makes any difference other than to take the orifice of the carburetter above the body of the car. There are three basic problems with the carburetter and as we have not reached a final conclusion on these I feel reluctant to give any other information other than to point out the problems. Also, we have found no advantage in opening both throttle butterflies at once. In fact quite the opposite.

The first problem is that the carburetter is fitted with an anti-emission device which is controlled by a vacuum operated plunger. This is designed so that when Bill Bloggs takes his foot off his Cortina's throttle, the vacuum will close off most of the petrol supply to prevent unburnt petrol coming out of the exhaust. Unfortunately the vacuum device is not instantaneous and can play havoc with pick-up on the circuit.

The next two disadvantages are combined. There is a third and supplementary jet by way of a spray tube into the venturi. When the throttle is fully open and golloping lots of air it sucks through the spray tube a certain amount of petrol through a small jet to supplement the main petrol supply. The pick-up for this supply is located rather high in the float bowl, resulting in the following situation. On right-hand corners when the petrol surges to the outside of the carburetter, the pick-up orifice is left high and dry and starvation occurs. The opposite happens on a left-hand corner when a mass of petrol is forced through the spray tube just when you don't need it. The first situation can obviously be cured by float level but this makes the second situation progressively worse. If you find a satisfactory answer, please tell me!

Final setting-up and tight running in is best carried out on a fixed dynamometer. This can be hired for about £30 per session and is well worth while. Rolling road dynos don't give you the same accuracy, apart from many other disadvantages.

The standard engine produces about 90 bhp; with a little luck you should see figures 105-108 bhp at 6250, dropping to 102 at 7000. If you do you are right in the ball park. Provided, of course, you can drive like Derek Lawrence!

Bore 80.978mm
Stroke 77.62mm
Comp ratio 9.5:1
Max torque 104 lb. ft. at 4000 rpm
Max power 105-108 at 6250
Max revs 7000 rpm
Cam timing inlet fully open at 109° ATDC exhaust fully open at 109° BTDC
Tappet cold inlet 0.012in. exhaust 0.015in.
Points 0.025in.
Ignition timing 53° max advance approx
Head 70-75 lb. ft.
Mains 60 lb. ft.
Rocker pillar 25-28 lb. ft.
Big end 32 lb. ft.
Flywheel 45-50 lb. ft.

. . . and now from the cockpit

Derek Lawrence's highly successful Titan Mk.6 Formula Ford has become the car to beat at Silverstone, with seven wins in seven starts there. Lawrence currently leads the *Daily Express* Championship, is lying 2nd in the Tate, 3rd in the Sunbeam Electric and 3rd in the BOC. So you can imagine our response to an offer of a test drive.

For once the weather was on our side, and the tarmac of Silverstone's club circuit was bone dry. We watched from the pit counter as Derek took the orange Titan out for some warming-up laps. Ten minutes later I was climbing in myself. I soon felt at home in the driver's seat, the right-hand change for the Hewland gearbox being perhaps the most difficult control to get used to. The non-synchro, straight-cut box won't tolerate a lazy change, but responds well to clean changes; its design allows very fast ones provided the revs are right. Apart from the rev-counter, there's an oil pressure gauge, temp gauge and, of course, the mirrors to scan. The driving position is almost horizontal and with the crutch and shoulder straps done up really tight its a bit like being in a strait jacket until you're actually on the circuit, when it feels absolutely right. The owner ran over the controls: "Don't exceed 6800 revs. You'll find the gearbox has a normal 'H' pattern with reverse to the left. Can you reach the pedals properly . . . ?

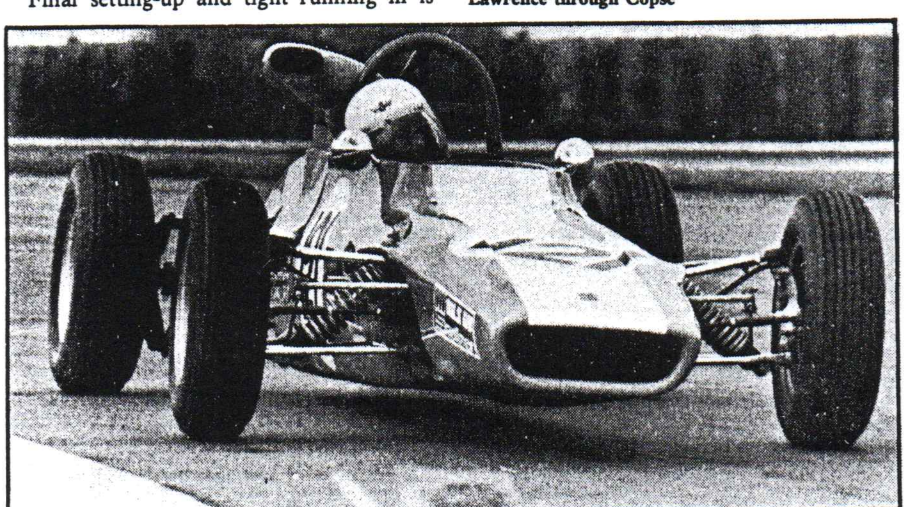
I set off gingerly past the pit counter. The controls felt beautifully precise and light and the engine was more responsive than I had imagined. After a few laps I was beginning to feel at home with the car, but finding it difficult to fix braking points on a road that seemed so large after the familiar narrow slopes of Shelsley Walsh and Prescott. I was also aware of taking rather odd lines through Woodcote and Becketts, but my biggest worry of all was keeping out of the way of Francois Cevert, who was circulating at an incredible pace in the new F1 Tyrrell. Knocking up times some four seconds below the official lap record, he seemed to be permanently looming in the Titan's mirrors.

After six exploratory laps I came in. Titan's Roy Thomas had arrived to help sort out some handling problems, so while he changed the rear springs I talked with the owner about braking points. After lunch I put in four more laps, which were much more organized, but it was not until the end of the afternoon when I was allowed a generous drive of 10 laps, that things began to fall into place. Chopping down into third from Copse, it was easy enough to hold the car in a neutral slide provided the car was on the right line. It was then flat through Maggots and into second for Becketts. The Titan would then pull 6800 rpm in top down the straight to Woodcote — around 124 mph. Derek had warned me about the front nearside wheel locking under braking, but previously I hadn't been pushing that hard. Now, leaving the braking as late as I dared, the wheel was locking as I approached the grandstand. The times were coming down and I found I could keep pace with another Formula Ford that was circulating, actually gaining down the straights where the superior power of Titan's blue-printed engine began to tell — that in Derek's car is one of their special units, which cost about £450 and requires up to 40 man hours to build. It is also interesting that the chassis — designed and assembled by Titan from Arch Motors parts — has hardly changed at all since they first entered Formula Ford many years ago. Yet it is still ultra competitive.

My final times were just over three seconds outside the Formula Ford record — which suggests that with a good car like this it would not be difficult to get within a second or two of a really good time, in private practice. One thing's for sure — the only thing stopping me putting in a 63.8 second lap was me. The car was what you might call 'ansome.

Gordon Bruce

Below: Bruce trying in vain to emulate Derek Lawrence through Copse



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