Engine Test No. 14

by Mike Billinton

Super Tigre X21 Car Std

THIS BASE-MOUNTED 3.5cc car engine provided interesting changes to test procedures — both for the novel mounting style used, and for its possible effect on manner of performance. Also of interest was the inevitable comparison with the earlier 'X21 RE80' car engine (tested 'Model Cars' Winter 1981). Irrespective of a particular motor's standing in relation to other makes, of equal (maybe more) interest is any evidence of developmental progress by the manufacturer concerned.

In very brief terms this test showed the 'S21' to be a definite leap forward compared with the earlier 'RE80' (though not yet at the top level of *OPS* or *Picco* in sheer Tuned pipe/BHP terms) and probably as a consequence of the base-mounting, the vibration-free running at all RPM levels was exemplary — the best yet.

This 'S21' unit was provided by *Tigre Engines UK* and is the most recent engine produced by the Italian *Super Tigre* factory for 1984 1/8 scale competition class.

Mechanical Details:

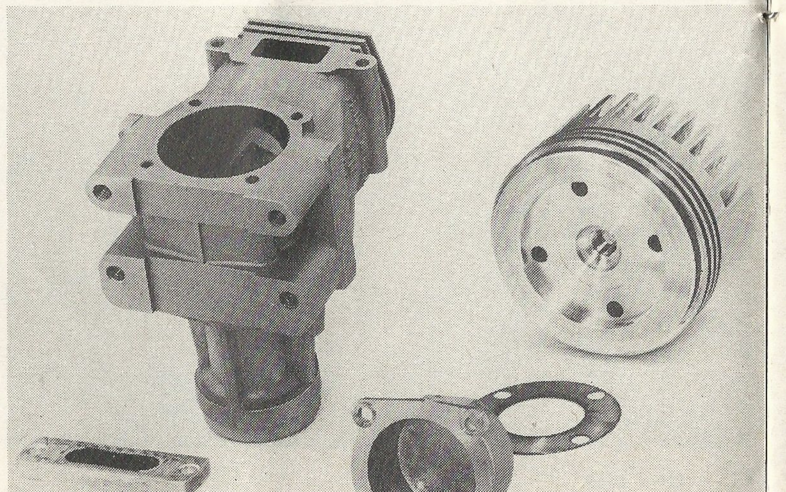
There are several significant changes compared with the earlier 'X21' unit.

Crankcase. Externally the most striking change is the 'non-aircraft' style of base-mounting, pointing the engine specifically towards car usage.

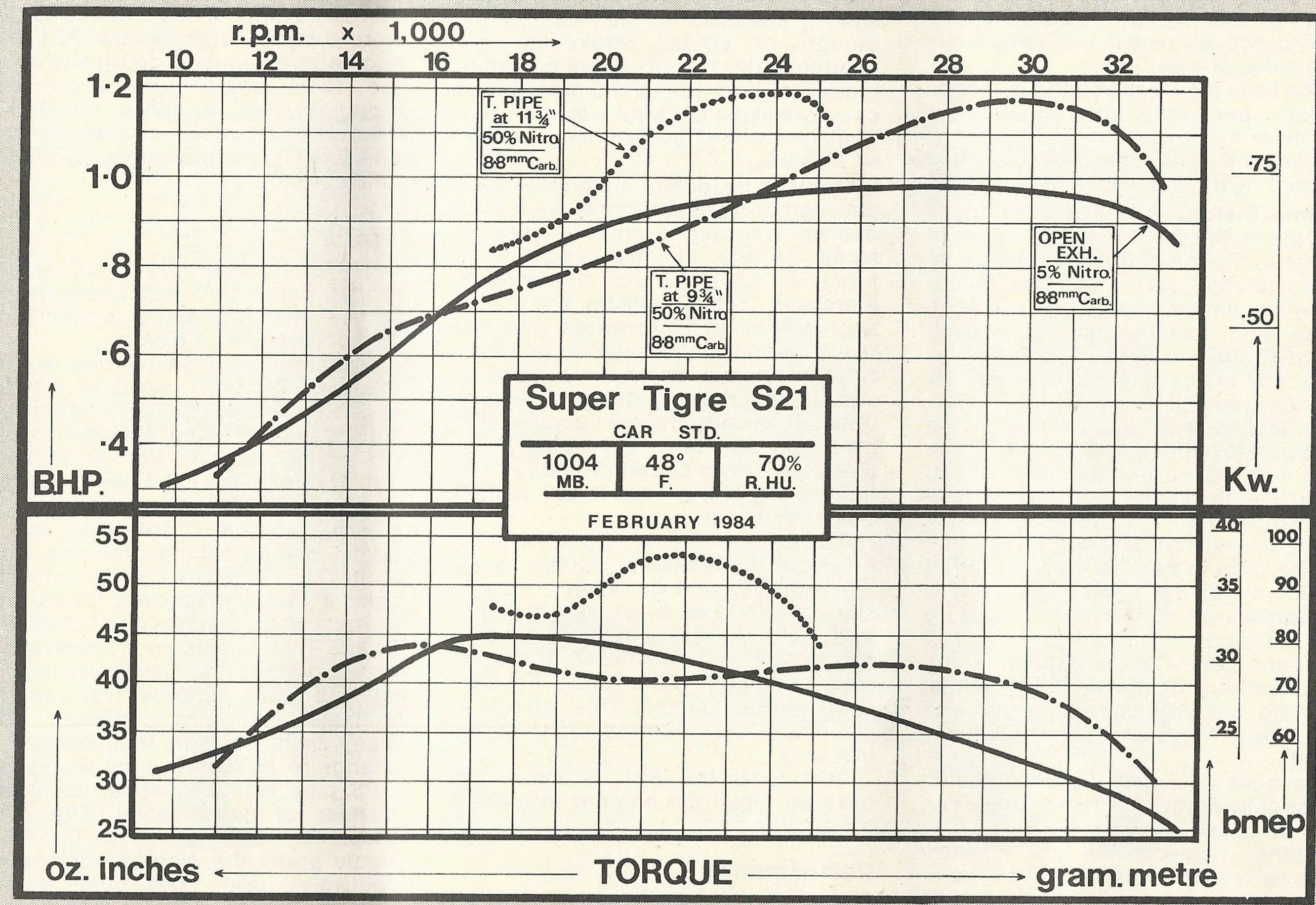
As the 'X21' crankcase itself had considerable merit, *Super Tigre* have built on that by modifying the crankcase die. The additions then, are the 2 massive below-lug 'pillars' — internally threaded at each of the 4 corners — for mounting directly to the car chassis plate. More vital additions are the 4 vertical diagonal webs above the original lugs — added in the hope of restraining the more troublesome cylinder/head vibrations. The original beam mounting lugs still remain embedded and unmachined in the side of the case — there being production advantage in their retention for possible alternative use.

Internally the boost passage is of considerable cross-sectional area — this one wide passage feeding the 2 Boost ports in the liner. This boost passage is of similar size and shaping to *Super Tigre* earlier 'modified cross-flow' style Transfer passage (ie. the type used before Schnuerle porting proper became fashionable in model engines). Added to that, large boost passages are the 2 normal side Transfer passages having moderate cross-section only and tapering gradually towards the top — to accelerate gas-flows. These two ports are angled as usual away from the exhaust port. In total then, the transfer passage throughway is quite large. One of the 2-stroke compromises is involved here: provision of enough cross-sectional area to prevent undesirable restriction to gas flow, whilst also aiming to generate sufficient gas-flow speed by an accelerating venturi effect. At the same time not to undesirably increase sub-piston crankcase volume which harms Primary (crankcase) compression and on which the 2-stroke here depends, to pump fuel/air up to the cylinder. The considerable variables involved are enough to ensure that uniformity of approach is a long way off yet (and a good thing too!)

The 'S21' crankcase also provides a trouble-free carburettor mounting stub

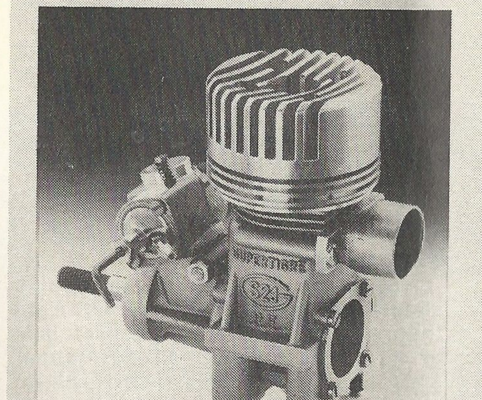


Above: the purposeful looking Super Tyre 'S21 RE' complete with ST 8.8mm twin-needle MAG carburettor. Slide barrel carburettors are available from Tigre Engines UK. Right: crankcase housing, exhaust stub, backplate and cylinder head.



Super Tigre S21 Car Std

Dimensions & Weights:
Capacity — .212in. (3.473cc)
Bore — .6538in. (16.6mm)
Stroke — .6313in. 16mm nominal)
Stroke/Bore ratio — .966/1
Timing Periods — Exhaust — 157°
Front Induction — Opens 41° ABDC
Transfer — 126° — Closes 55° ATDC
— Boost — 126° — Total 194°



Exhaust port height — .213in.
Combustion chamber volume — .34cc
Compression ratios — Effective — 7.77/1
— Geometric — 11.2/1
Squish band clearance — .020in.
Squish band width — .14in.
Squish band angle — 2°
Crankshaft diameter — 4715in. (12mm nominal)
Crankpin diameter — .1963in. (5mm nominal)
Crank bore — .350in. (8.9mm)
Nose thread — .245in. × 28 TPI (¼ UNF)
Gudgeon pin dia. — .1572in. (4mm)
Con-rod centres — 1.181in. (30mm)
Weight overall — 11½ozs (.326 Kilo)
Mounting holes — 34.5mm × 18mm with 4 holes 4mm × .75mm
Width — 1.665in.
Length — 2.475in. (to front of bearing)
Height — 3.44in.
Frontal area — 5.2 sq.in.

Performance:
Max. BHP — 1.19 at 29,890 RPM (OPS pipe 11 ¾in./50% Nitro)
— .98 at 28,000 RPM (Open Ex./5% Nitro)

Max. Torque — 53oz.in. at 21,950 RPM (OPS pipe 11¾in./50 Nitro)
— 45oz.in. at 17,200 RPM (Open Ex./5% Nitro)

R.P.M. Standard Propellers:
8 × 6 Zinger — 15,850 (Open Ex./5% Nitro)
7 × 6 Taipan — 18,620 (Open Ex./5% Nitro)
7 × 4 Taipan — 23,710 (Open Ex./5% Nitro)
7 × 4 Zinger — 24,490 (OPS pipe 9¾in./50% Nitro)

Performance Equivalents:
BHP/cu.in. — 5.61
BHP/cc — .342
Oz.in./cu.in. — 250.0
Oz.in./cc — 15.26
Gm. metre/cc — 10.94
BHP/lb. — 1.65
BHP/Kilo — 3.65
BHP/sq.in. frontal area — .228

Manufacturer:
Super Tigre SRL, Bologna, Italy.

UK Distributor:
Tigre Engines, 97 Tudor Avenue, Watford, Herts.

and a rear-exhaust layout. However, most of the 'X21's' exhaust-biassed cooling fins are now milled away flush with exhaust port.

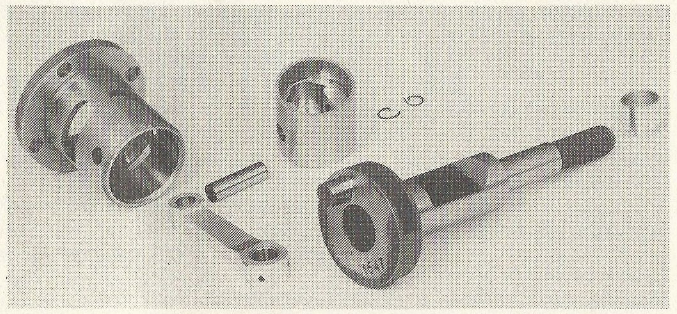
The front main ball bearing is rubber sealed, and the other fuel-saving device is the usual grooved crank bore — connecting the base of carburettor to front bearing.

Liner/Piston. Another significant change is the large diameter, thicker flange to the top of the chromed Brass liner. (30mm dia. × 3.5mm thick). Having cylinder head bolt clearance holes and virtually nil piston-deck height, it reduces appreciably, distortion or heat expansion problems, i.e. the usual liner flange can allow cylinder head bolts to tilt and stress the whole surrounding area, and its a common finding that piston fit at Top Dead Centre varies with bolt torque. The large flange reduces this problem. The semi-related question of whether to use plug-in head or have chamber flush with top of cylinder — as here — recognises the difficulty of dimensioning the plug-in fit to suit a variety of material combinations and running temperatures. By the neat expedient of evading the problem altogether with this flush-type combustion chamber/head.

Vestiges of *Super Tigres* modified cross-flow porting remain — these can now be called the Boost ports — whilst in other respects the porting now follows recent advanced Schnuerle 5-port layout, i.e. 1 Exhaust, 2 side Transfers, 2 Boost. All Boost/Transfers now open simultaneously at 126° (more simply than the 'X21's' 126° Boost/122° Transfers/106° Perry style Transfers). Exhaust remains though at a rather low 157° for tuned-pipe use. Bore size tapers to a 0.0015in. smaller size at TDC.

Piston is in high-silicone, and is finely milled from solid. The larger bore now used makes the 'S21' an 'over-square' unit as opposed to the X21's 'under-square' dimensions; i.e. *Super Tigre* now revert to standard bigger bore than stroke.

Connecting-rod is machined from solid high-duty aluminium alloy. Tapering (in side view) reduces stress-focussing at both big and little ends. The rod is phosphor-bronze bushed at big-end only.



Right: 'S2' internal components. Note the 'minimal distortion' flange on the liner.

Crankshaft in Nickel-chrome steel is almost identical to the 'X21' crank, though of course stroke is now shortened (by 1mm to 16mm nominal). Induction bore is still 8.9mm. Slotted counterweight to crank webs is used. Timing now opens and closes some 5° — 7° earlier.

Cylinder-head is of aluminium alloy and partial heat-sink style. As it is of deeper non plug-in style it takes on some of the cylinder cooling fin function. Squish band clearance is increased .003in. to .020in. and is now angled a small 2° upwards. The net result though of changes to Bore/Stroke/Combustion chamber volume/squish details, is a ½ unit increase only to what was a quite low Compression ratio, so its now still only 7.7/1 Effective. This is bound to lead to good engine reliability but can restrict potential power.

Carburettor. Super Tigre's almost universal twin-needle 8.8mm MAG barrel throttle unit was used — it plugs straight into case. As an aside its rather strange to be using this same carburettor in tests on both the 3.5cc racing engine and the 20cc S.T. Large scale aircraft engine! This reflects in the main the differing RPM levels involved.

At 11½ozs the 'S21' is one of the heaviest Open car engines in current production.

Performance

Only, brief running-in proved necessary, with RPM's holding steady at a very early stage. ABC piston/liners are renowned for quick break-in, and possibly the S21's 'minimal distortion' liner flange enhances this yet further.

Provisional standard propeller RPM's in Open Exhaust format were a matter of some excitment — beating by a fair margin virtually all other engines tested so far.

Test 1

Open Exhaust; 5% Nitromethane and 15% Castor oil; 8.8mm carburettor. Plug - Rossi 8.

The Torque figures equally reflected the fine RPM levels on standard propellers — at maximum, the 45oz. in was a 28% increase over the 'X21'. The resultant final .98 BHP at 28,000 RPM placed the 'S21' right among the leader and in these open exhaust terms, only the earlier *Picco* S/E and *OS* '21VR' were superior. Just like the 'X21', this engine threatened to go on and on up the RPM scale with each load reduction, so prudence dictated a 'hold' at 33,430, solely to keep motor in one piece for the more arduous trials to follow.

Test 2

OPS Tuned pipe (9¾" plug to end rubber can); 50% Nitromethane 5% Castor with 10% ML70 synthetic oil; 8.8mm carb. Rossi 8 plug.

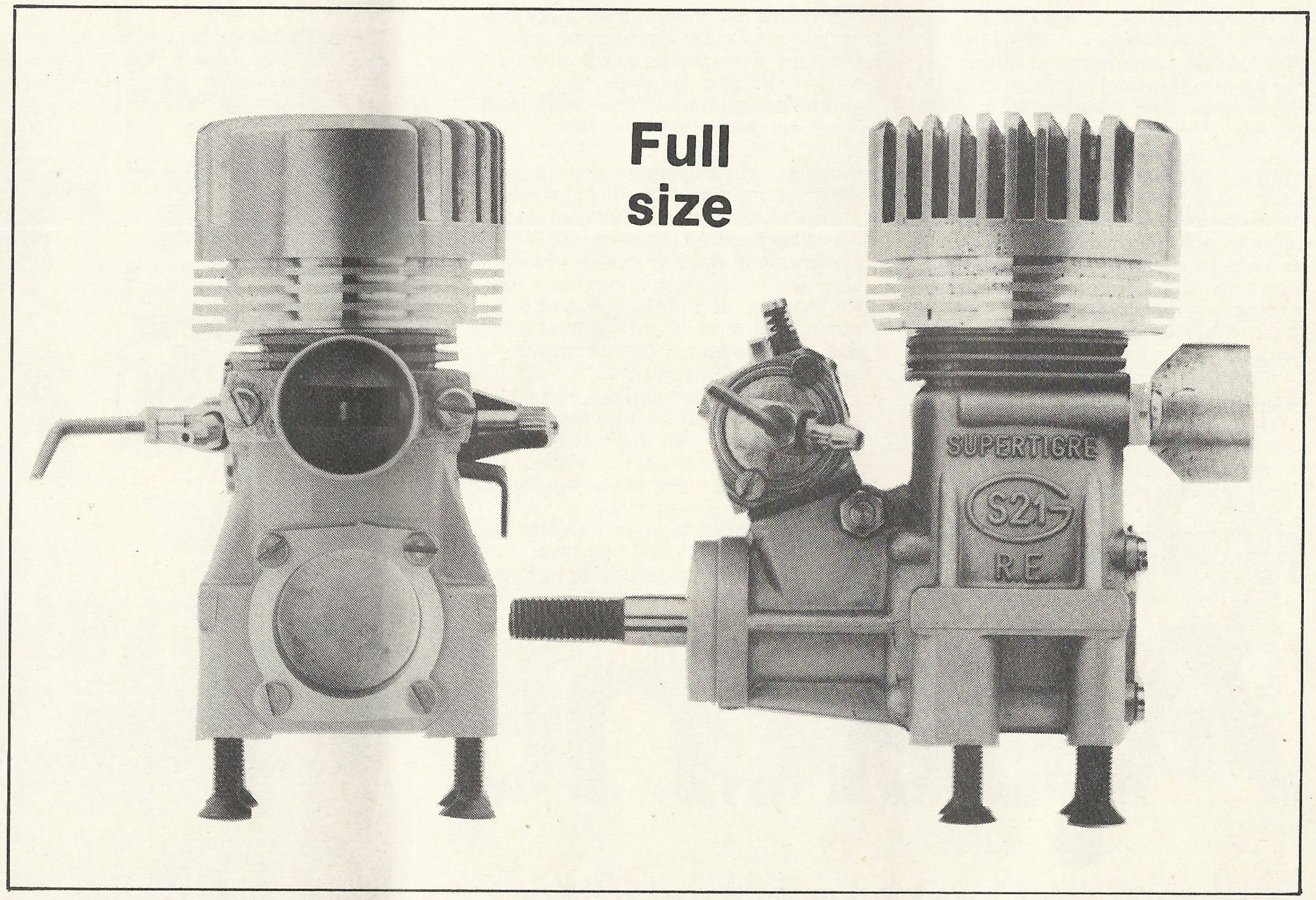
A naturally keen anticipation was felt following Test 1 . . . was this to be the first to exceed 1.5 BHP in standard ex-factory layout? The straight answer proved to be — no, a situation reminiscent of the *OS* 21VR, the fierce-some Open exhaust performance of which was not followed by a commensurate tuned pipe and Nitro uplift. The 'S21' never really came 'on song' in that familiar clean fashion and the best figure reached was 1.18 BHP at 29,890 RPM. Suspicion at this less than usual uplift fell first on the pipe itself — had the hidden internal rear cone for example thermally collapsed after many tests at high temperature? A change to an identical but brand-new *OPS* pipe led to identical result and manner of performance. The other suspicion was that maybe the 'S21' would prefer the more normally competitively used (and *OPS* recommended) length of 11¾in. from plug to end of can? A set of figures was therefore arrived at using this longer length and led to the abbreviated curve shown on graph; i.e. a very slight increase to 1.19 BHP — but shifted as usual to a lower resonant RPM point of 24,560, and with the normal marked torque fall-off past that point.

It must be remarked that, other than the indecisive exhaust note on pipe (also reminiscent of the *OS* '21VR'), the motor was otherwise totally happy — no plugs burning out; no signs of heat distress, pipe well sealed and aligned carburettor setting optimised at all points, and barely any change whether pipe was under or over-cooled. Much of this points to possible under-compression (as noted on *Cipolla* 3.5), though here the 'S21' is not so far off the norms for compression ratio and squish band clearance.

Test 3

Equipment as Test 2.

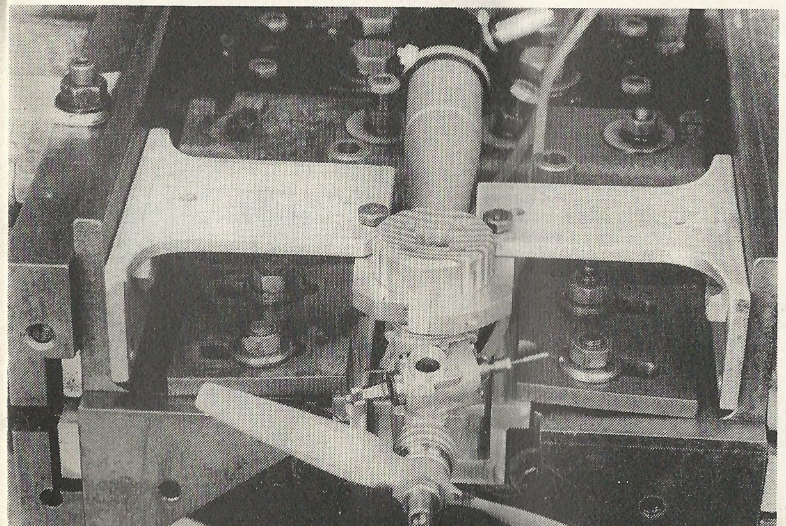
Not a power test this time, but a simple mechanical test in line with a pet theory of this tester that rigidity (or lack of it) has a large effect on manner and/or scale of performance. As photo shows, a cylinder head restraint was applied so that minimal motion was possible, where under normal circumstances the cylinder head can oscillate severely at certain RPM points.



The restraint was designed to prevent movements in any direction other than the slight upward heat expansion direction — photo makes this clear. It was felt that the base-mount 'S21' would be an ideal choice for this test — because the vertical over-hang was greater than with the normal beam-mounting. The actual engine mount itself is a light-alloy milled U-channel section serving to bring crankshaft centre-line of the base-mount unit into alignment with the Dynamometer pivot axis.

As it turned out, the engine could not have been a worse choice for this particular test, because its 'unrestrained' performance proved so rigid and stable, that when the 2 final restraint bolts were tightened there was *zero* change to engine note, RPM, Torque. This ON/OFF procedure was repeated at 4 widely different RPM points — all with identical result — No change.

So, that looked like a waste of time and the destruction of a pet theory. The principle though will be pursued in a future engine test — because its undeniable that some engines can, at certain RPM points, suffer severe oscillations around a horizontal axis passing through both lugs and crankweb.



Left: the author's 'cylinder-head restraining equipment almost enveloping the 3.5cc size 'S21' engine. This rigidity test will be carried out on other engine types in future issues.

Summary

Another intriguing test, leaving some questions unanswered. The 'S21' nevertheless performed exceedingly well in Open exhaust format — though below potential on pipe.

It would be unreasonable however to expect any Manufacturer to do *more* than significantly improve the previous product; and improvement there certainly was here. Change was almost inevitable in view of the various detail modifications undertaken — sufficient in fact to make the 'S21' a very different engine from the earlier, 'X21'. Also in fairness to *Super Tigre* (and any other manufacturer involved), with each test there remains the continually uncertain question of pipe style and related parameters. After all, the *OPS* pipe has been used as a 'bench-mark' — but, it may not be the ideal for each specific engine. However, no Tuned pipe (in current car style) was provided for this 'S21' and, neither was it for that *OS* '21VR'.

Equally though, it has become apparent during the tests on many different engines — on a variety of Tuned pipes, that *large* power differences are unlikely to accrue from use of an alternative pipe on a particular engine whilst that engine's other parameters remain unchanged.