Origin of the Species...

A Brief History of the **AJP/SPEED 6**

Much has been written and discussed about the original design of the AJP6 which became the TVR Speed 6 engine, with many suggestions that Al Melling's original design was flawed. However, with the emergence of a complete set of blueprints for the AJP6, it has now become possible to compare the design of the engines as conceived by Al Melling, with the actual internal dimensions and layout of the production units fitted to the production TVR Speed 6 engine.

A bit of history is appropriate at this point, so in the mid nineties Al Melling of MCD (Melling Consultancy Design) was asked by TVR to design a new straight six engine for their new cars. The original plan was for a 3.0 litre and 3.5 litre 24 valve unit to compliment the 4.2 and 4.5 litre AJP 8, so that TVR would have good range of engines. The idea for a 3.0 litre was soon dropped, however, with its place taken by the 4.0 litre. Al designed and built five or six engines which were delivered to TVR for evaluation. It was then that the stories of failures, flawed design and the need for a complete redesign came out of TVR.

It's well known that the production Speed 6 engine suffered from reliability problems and again the source of that unreliability has been put down to factors such as inherent design flaws, poor component quality and owners abusing the engines before the engine oil reached the recommended correct operational temperatures. The result of these isolated or indeed complimentary issues resulted in failures such as pistons, and excessive wear of the valve guides and finger followers, the latter of which was originally identified by Al as being due to the valve train geometry being altered from the original design.

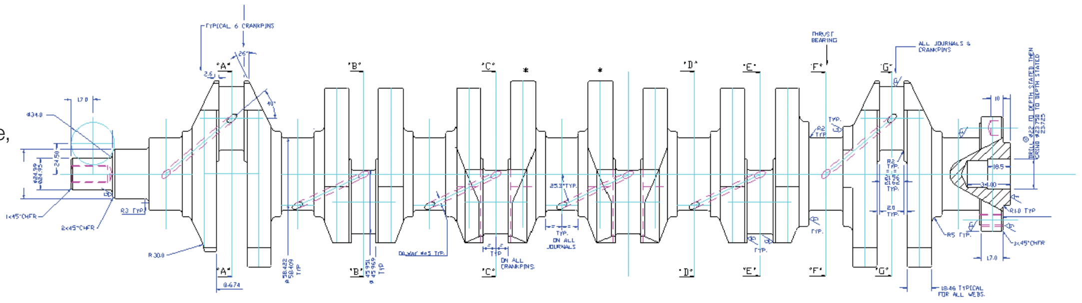
In this article we have been in discussion with David Davies who now owns the original drawings for the original MCD designed engine, which has enabled a comparison of the original engine against the production engine. The opinions within this article are those of David Davies, however the point of this article isn't to apportion blame or point fingers, but to highlight the differences and let you decide....

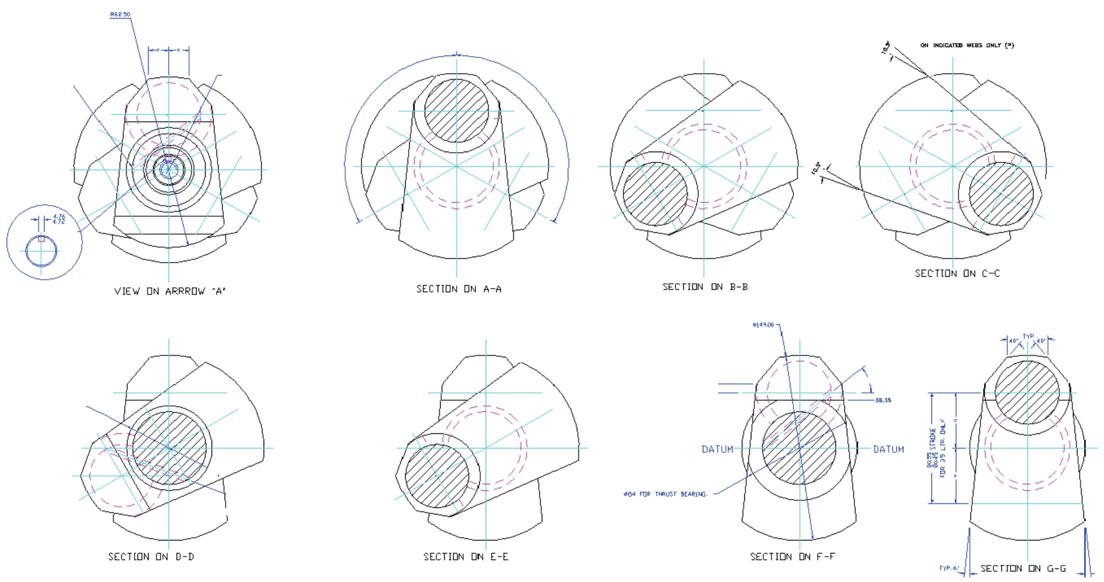
Design differences?

The drawings on this page and others in this article are extracts from the actual MCD engineering blueprints, so you can judge for yourselves where the main differences are from the original Melling design.

CRANKSHAFTS

Looking at the heart of the engine, the crankshaft, there are two drawings in existence, one from steel billet EN40C and the other iron, both intended for the 3.5/4.0 litre.





The journal diameters are also not the same; on the MCD designed steel EN40C crankshaft the journal width is narrower, the journal diameters were 45.951 mm and the main bearings were 58.420 mm, all of these specification changes are detailed on the right hand side of the drawing.

When the TVR production engines appeared, the stroke had been increased on the crankshaft to 83mm for the 3.6 litre engine. The 4.0 litre stroke stayed the same at 92mm, though the big end journals were increased to 50.8mm for the big ends, and to 63.5mm for the main journal, which was also made wider by 1.25mm.

The crankshaft is 660mm long from the rear main bearing to the front main bearing, and the nose is another 127mm: that adds up to a total length of 787mm. The distance from the rear to the front main journals remains the same as the original design, with only the nose being lengthened.

One of the problems with the Speed 6 engine is torsional vibration; this is caused by the rotational mass of crank rods and pistons, which is in two parts: the crank and the bottom half of the rod (big end) is the rotating mass, and the top half of the rod (small end) and piston is a reciprocating mass.

To understand the reasons for this vibration let's take a look at the 4 litre engine. The conrod small end is heavier than the big end, so the rod is out of balance.

Other factors to consider are the longer throw on the crank and the larger big end journal size, this is all extra rotating mass and with the small end having extra reciprocating mass this makes it very difficult to balance it correctly. If we consider the MCD design, in my opinion you have a balanced, lighter rod, smaller big end journal and a shorter stroke, therefore less rotating and reciprocating mass with the result that a damper is not required.

The addition of the nose was another change to the crankshafts by TVR and was added to accommodate a fluid damper to reduce the torsional vibration. The damper is actually the same as that on a small block Chevy and should be available from any US parts supplier. A point to note, however, is that the damper weight is 5 kgs, which is a heavy part to add to a lightweight race orientated engine. On the early production cranks, the nose is actually a separate item held on by an extra long damper bolt.

Just to confuse matters further, there is a picture in existence of an S6 development motor running at full load on the dyno, reputedly undergoing testing for TVR. However, if you look carefully at the block, this engine is missing its damper, and there is no oil filter on the exhaust side, and neither does it have any oil returns on the side of the head and block, the latter two being features of the original MCD design. (please see the photograph on pages 8-9)

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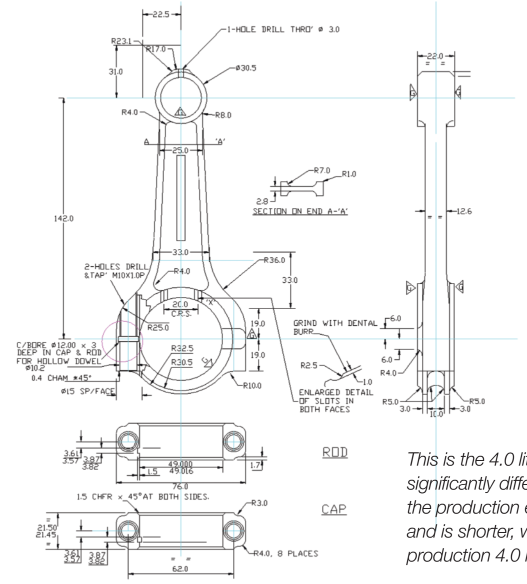
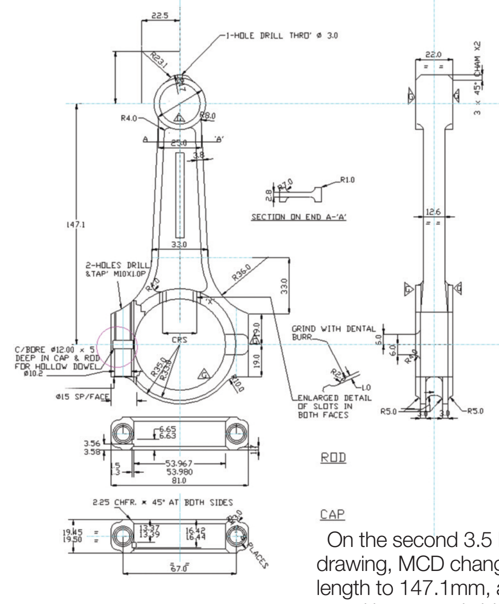
CONRODS

As previously mentioned it's necessary to be aware that the small end (top part) of each rod is a reciprocating mass and the big end (bottom half) is a rotating mass. As these are differing forces it requires conrods to be balanced in two parts: small end and big end. The rod length is measured from the centre of the small end to the centre of the big end, thus rod ratio is the stroke divided into the conrod length.



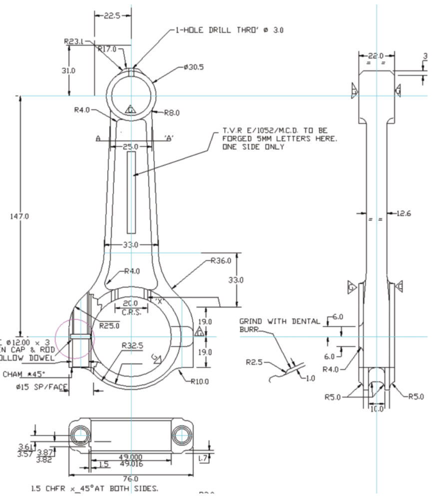
This is the 4.0 litre conrod drawing, this is significantly different to the one used by TVR in the production engine. This rod is better balanced, and is shorter, with the big end narrower than the production 4.0 litre rod.



On the second 3.5 litre conrod drawing, MCD changed the rod length to 147.1mm, and the big end bore now is bigger to fit a 50.8mm journal; once again the big end width is narrower than the production TVR crankshaft journal.

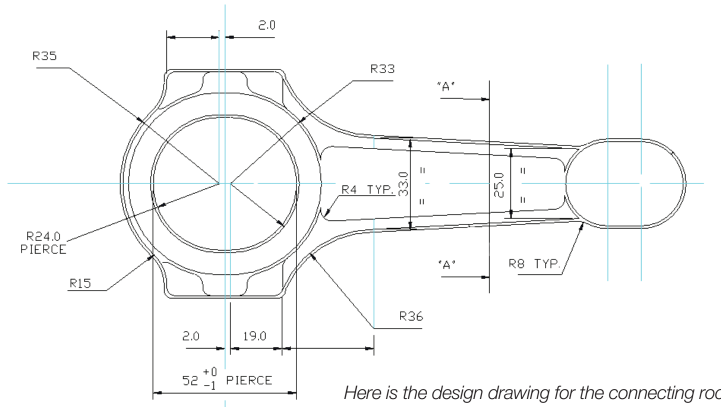
As you can see from the 4.0 litre conrod drawing, this is not the same rod that is fitted into the production engine. The AJP 6 big end bore is smaller than the production rod to fit the crankshaft big end journal of 45.951mm, and the rod length is 142mm. This length was retained in the early production engines but the big end bore was made bigger to fit the TVR 50.8mm big ends; in later engines the rod length was changed to 144.5mm.

If we consider the AJP 3.5 conrod we have two drawings for this: one rod is slightly shorter than the other at 147mm and the big end bore is smaller to fit a crankshaft journal of 45.951mm, whilst the big end width is narrower on both the 3.5 and 4.0 litre.



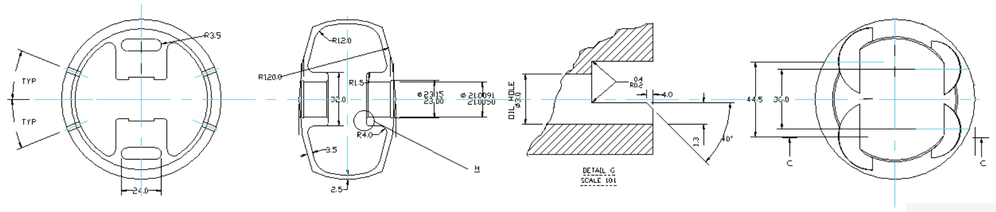
This is the 3.5 litre drawing for the conrod (note: this is not a 3.6 litre rod). The rod is shorter than that on the 3.6, and also the big end journal width is narrower.

The last drawing shows a blank forging, a 'one size fits all' which can be machined to any length or width that is required, by boring the small end and bushing it to the gudgeon pin size you need. The Production conrods were machined from this blank to the required dimensions.



Here is the design drawing for the connecting rod blank forging - i.e. before machining - a good example of 'one size fits all' engineering. Actually the big lump on the small end allows it to be finished to size for any of the TVR engines. This is the rod that ended up in the 4.0 litre.

If any of you have seen a 4.0 litre conrod you will see the lump on the small end. The problem with this rod is that the small end is heavier than the big end - making the reciprocating mass bigger than the rotating mass. Not good from the standpoint of vibration and harmonics, especially at higher rpms.



PISTONS

Now let's have a look at the differences between the piston designed by MCD and the TVR production piston.

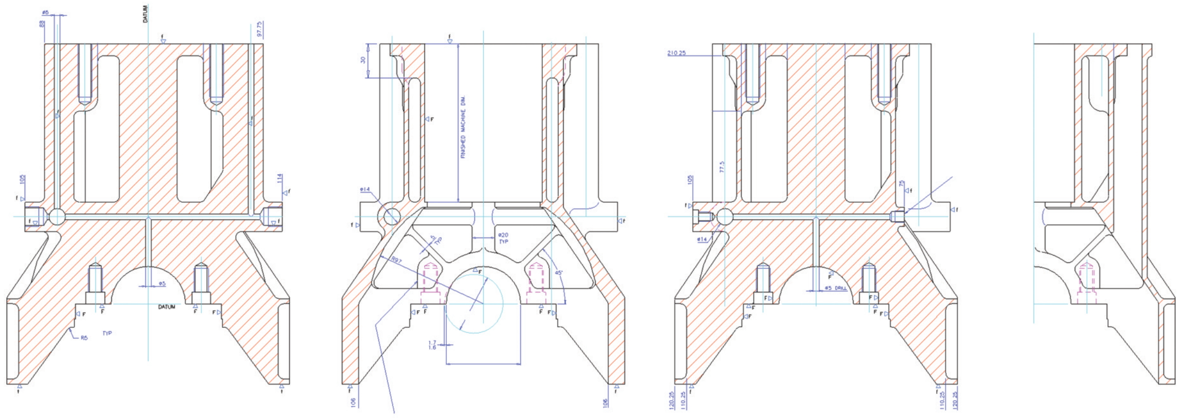
The piston pin, or gudgeon pin, is the same on both pistons, 21mm in diameter, and is a fully floating design held in by circlips. The pin height is 33mm - that is the distance between the centre of the pin and the top of the piston - and is also the same height as the early TVR production piston fitted to the short rod 4.0 litre engine.

However, the MCD piston valve reliefs were deeper at 6mm. The exhaust was 5mm, however the TVR production piston valve reliefs were reduced: inlet 4.75mm, exhaust 3.6mm. The dish on both pistons is the same, 75mm x 2mm deep in the production engine; this design of piston creates a compression of 11 : 1.

As for piston rings, the top ring on the MCD piston is 5.4mm down from the top of the piston and the ring width is 1.5mm. On the production piston, the top ring is 7.5mm from the top, and the ring width is 1.2mm. Second and third rings are closer to the top of the piston on the MCD design, and the rings are wider - the second ring is 1.5mm, and the third ring is 2.8mm width. On the TVR piston, the second ring is 1.2mm and the third is 2.5mm. Moreover, the MCD piston is specified as being forged, whilst the TVR piston is pressure cast.

Other changes made from the MCD design for the 3.6 litre include a higher piston pin height at 32.5mm or 1.260 inches. For the short rod version of this engine, the piston had no dish in it. For long rod engines the piston pin height was raised by TVR to 29mm, and on the 4.0 litre long rod engine, this went up to 30.5mm. Finally, to complete the picture, as the Red Rose engines had higher compression of 11.5 : 1, the dish was reduced to 1mm.

CYLINDER BLOCK



These drawings are cross-section views of the block design showing the details of the oiling system and the main bearing caps. Key points to note here are:

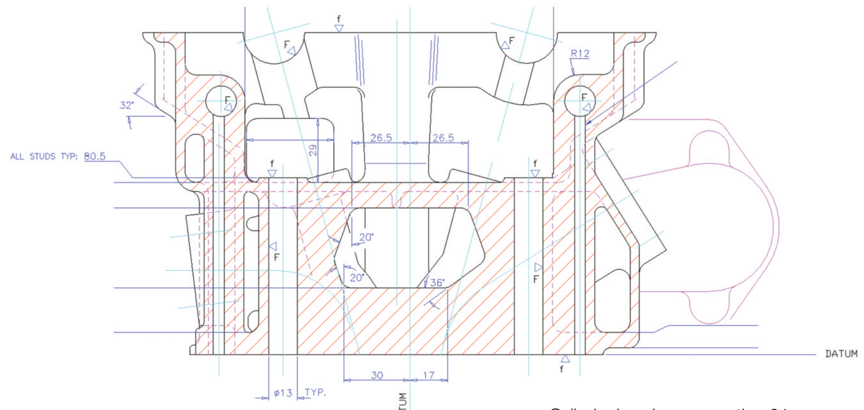
The original drawings provide for the main caps to be registered in the block and dowelled. In the TVR design, the caps are only dowelled, which in my opinion gives less support to the main bearing caps.

The oiling system, as originally conceived, featured a supply to both sides of the block, with four feeds to the head. TVR removed two oil feeds on the exhaust side and moved the oil filter to the inlet side.

The reason that four oil feeds were designed into this engine was both to enhance lubrication and to aid cooling in the head - especially on the exhaust side. The design as implemented by TVR meant the oil has to travel up to the head on the inlet side, across the head, and then down the exhaust side, this results in the hottest part of the engine being the last place to get any oil.

AJP 6 CYLINDER HEAD

If we look at the cylinder head cross-section image labelled Cylinder Head Cross-section 01 you can see two drillings from the head face up to round holes, these are the oil feeds to the follower shaft, two on the inlet side and two on the exhaust side.



Cylinder head cross-section 01

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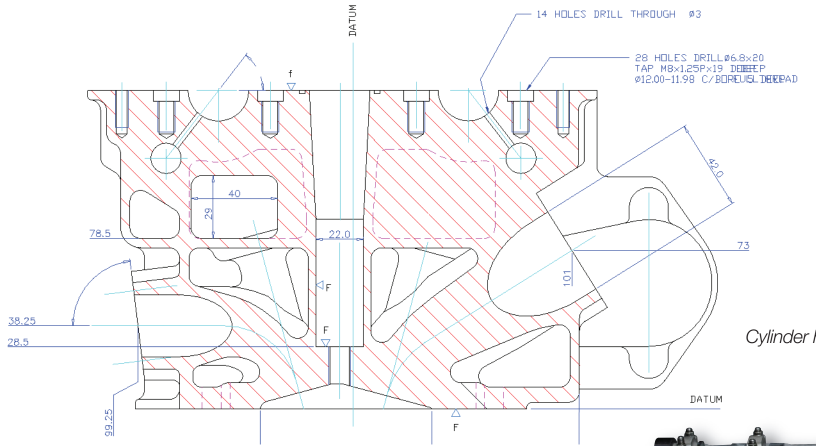
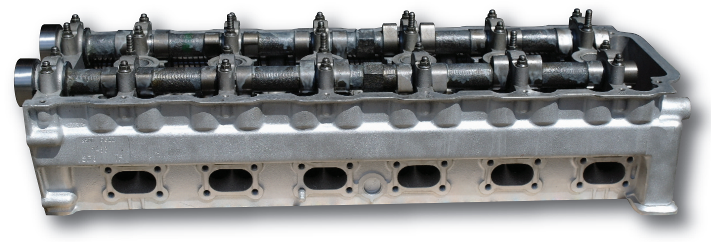
On the image labelled Cylinder Head Cross-section 02 you can see the oilway from the follower shaft to the camshaft bearings.

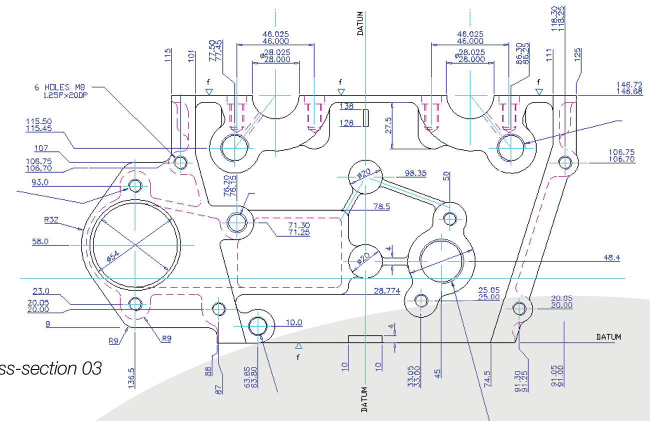


Cylinder head cross-section 02



On the MCD design, oil is fed from the main gallery along the inlet side, up the inlet side of the head between number 2 and 3 cylinders and 4 and 5 cylinders into the follower shaft, at the same time oil is fed across the block up the exhaust side between the same cylinders into the follower shaft. This oil flow then feeds the camshaft main bearings and the finger followers.

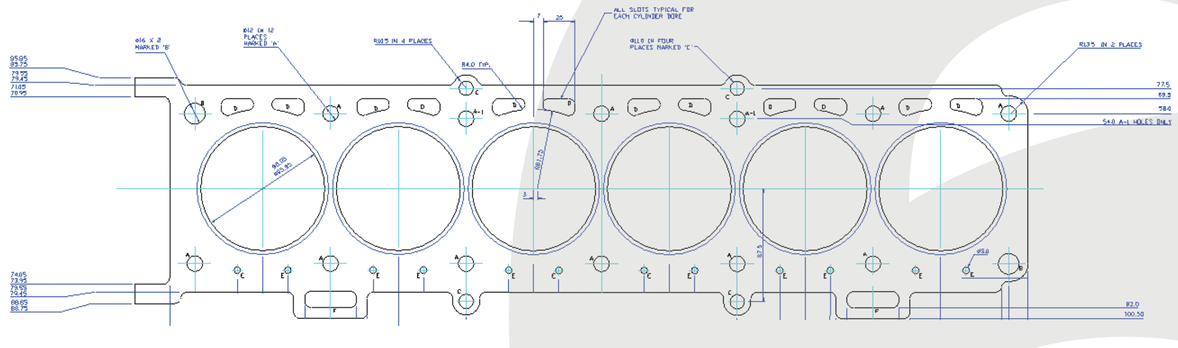
We will now look at the position of the camshafts. If you look at the cross section labelled Cylinder Head Cross-section 03, in the centre you will see the datum line above and each side you will see the camshaft bearing journals with a diameter of 28mm in the centre. Above that you will see 62.15mm and 53.30mm; this is the distance from the datum line to the centre of the camshaft bearing journals. If you add these two numbers together and minus the journal width you will get the distance from the inner edge of the inlet and exhaust bearing journals, which is 87.4mm - if you measure a TVR production head you'll find it is exactly the same. This suggests that one of the popular beliefs, and one held by Al Melling himself, that the camshafts had been repositioned, is incorrect.



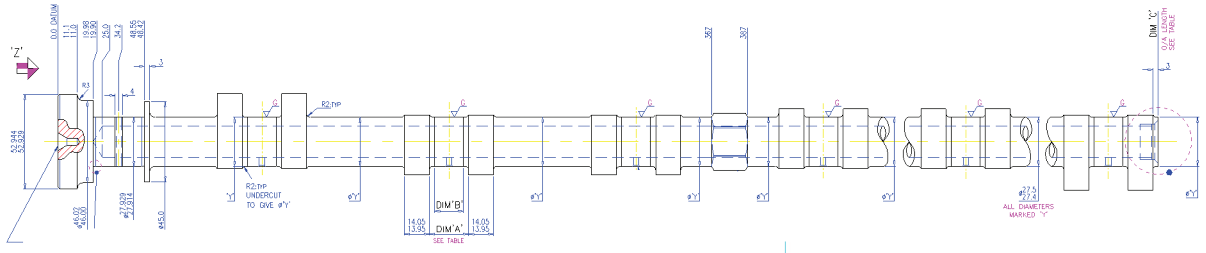
Cylinder head cross-section 03

AJP 6 HEAD GASKET

Here is the drawing of the head gasket. This is a bit different than the production gasket.

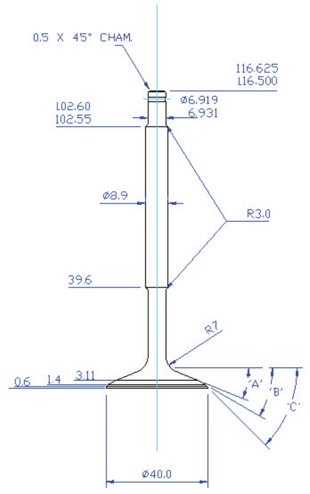


First, there are the waterways on the inlet side which are all open, and on the exhaust side they have 5mm holes to the head. Also visible is the oil return to the sump between 1 and 2 - 5 and 6 cylinders on the exhaust side - and the four oil feeds to the cylinder head. The gasket thickness when crushed is .060 thou of an inch or 1.5mm.



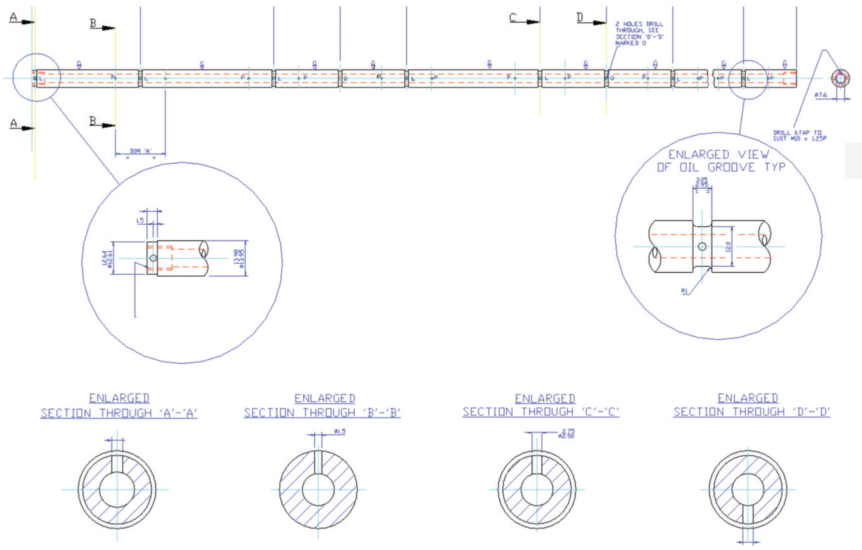
AJP 6 CAMSHAFT

As you can see from the drawing the exhaust camshaft is made from EN40B billet steel and is bored through the middle. The inlet camshaft is a mirror image of this. On the TVR production engines, the camshaft specification was changed to a sintered type and manufactured as a hollow tube with hardened lobes press fitted. The profile of the MCD development camshaft lobe too had more duration and lift than the production camshaft.



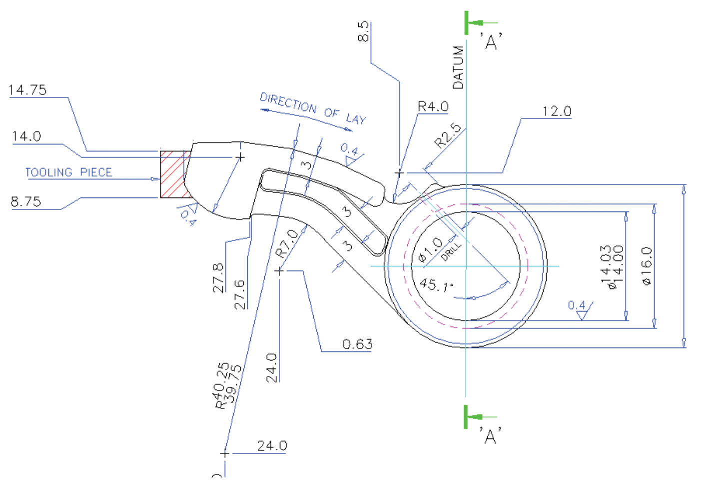
AJP 6 VALVES

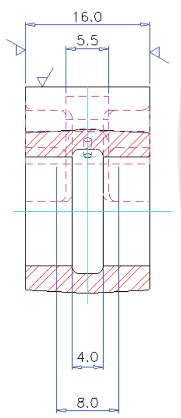
This is the drawing for the inlet and exhaust valves. You can see from these drawings that the MCD design has 9mm stems wasted at the top for the 7mm retainer, and valve head diameters of 40mm inlet and 32mm exhaust. The exhaust valve is 80% of the inlet valve. These valve head sizes made it through to the production valve but TVR reduced the stem down to 7mm. MCD redrew the valves for us when we purchased the blueprints from him in 2005, so the stems are now 8mm, everything else is the same.



AJP 6 FOLLOWER SHAFT

You can see from this drawing that the follower shaft is different to the production one as it has oil groves around the shaft. These are the oil feeds to the cam bearings - the other holes are for the finger followers.





AJP 6 FINGER FOLLOWERS

This drawing of the finger follower shows how the MCD design is totally different to that of the production engines. The shape is designed to follow the camshaft lobe differently; it also allows faster valve acceleration off of the valve seat. It is lighter by 8 grams and there is an oil grove inside for full 360 degree oiling, allowing oil to spray on the camshaft lobe constantly. Its design also puts less side loading on the valve stems.

AJP 6 SUMMARY

The earliest date on the drawings is 18-2-1995, but we have to assume that there must have been talks between TVR and MCD before this about the design of the AJP 6 engine.

It's likely that this would have been before Christmas 1994, and as I remember from my meetings with Al Melling, he told me that the brief was for a six cylinder engine of four valves per cylinder to produce 400BHP, to include delivery of a number of pre-production engines for evaluation.

Let's look a bit more closely at what he had designed. One of the biggest enemies of the engine is friction which produces heat, as a rule 15% of the power an engine makes is lost in driving it, so any way that friction can be reduced means the engine will make more power.

With the crankshaft, you can see from the drawings that the journal sizes are a lot smaller. The main journals are 5mm smaller, the big ends are 4.75mm smaller, the crankshaft is fully counterweighted, and the rods are also narrower - all this reduces friction; the conrods are better balanced and lighter, so reducing the rotating and reciprocating mass.

The piston is a forging - it has high ring location on all three rings but most importantly the high top ring as explained.

The oil system has a three stage dry sump system and one pressure pump. Oil is fed via the header tank to high pressure oil pump, from the oil pump to the filter, then through the main gallery to the crankshaft main bearings through the camshaft journals, also from the main gallery oil goes to the cylinder head via the four oilways, two each side of the block up to the cylinder head and into the follower shafts, feeding the camshaft bearings and the finger followers. These are fully oil grooved, giving a constant flow of oil to the camshaft lobes, not only for lubrication but also to help cool the cylinder head.

So overall, what are the consequences of TVR's deviation from the original designs? It's difficult to assess but in my view problems were created by removing the oil feeds from the exhaust side, which caused lack of oil to the hottest part of the engine, that's why when re-building an engine I add an oil feed to the exhaust side at the rear of the head to compensate for this. Another problem is the finger followers; removing the oil groove from the followers prevented a constant oil flow to the cam lobes which also aids cooling. TVR also changed the shape of the finger follower which created more side thrust on the valve stem causing excessive valve guide wear, allied to that it is also 8 grams heavier and does not follow the cam lobe correctly. Also, in my opinion, the valve spring pressure is too high which puts extra load on the valve seat and valve. As mentioned earlier, the 4.0 litre conrod is out of balance and the crankshafts are not well balanced either. It would have been better if they had machined and balanced them to a higher standard. The main caps are, in my opinion, terrible and not fit for purpose as they don't support the crankshaft properly and suffer from cap walk, the 4.0 litre more than the 3.6 because of the shorter stroke.

Credits

This article was written as a result of conversations between David Hothersall, Sprint Deputy Editor, and David Davies of RND Engineering. We would like to thank him for allowing us access to the original AJP6 blueprints and for sharing his opinions with us.

www.rndengineering.co.uk

SHORT BLOCK

Short Block TVR		Bore: 3.780in	Stroke: 3.170in
No. Cylinders 6		Cylinder Volume: 582.95cc	Total Vol: 213.4ci

CYLINDER HEADS

Cylinder Heads: 4-Valve Head/Stock Ports and Valves

Valve specifications:

Intake Valves/Port:	2	Exhaust Valves/Port:	2
Intake Valve Dia:	1.575 in	Exhaust Valve Dia:	1.260 in

COMPRESSION

Compression Ratio: 11.75

Combustion Space: 54.23cc — Cylinder Volume: 582.95cc

INDUCTION

Induction Flow: 1500.0 cfm@1.50inHg — Fuel Types: Gasoline

Manifold Type: Sequential-Fire Injection — Nitrous Injection: 0.0lbs/min

EXHAUST

Exhaust System: Small-Tube Headers

CAMSHAFT

Cam Name: Stock Street/Economy

Cam Installed Advanced(+)/Retarded(-): 0.0

True IVO: 34.5 — True EVO: 74.5

True IVC: 70.5 — True ICA 108.0 — True EVC: 30.5 — True ECA: 112.0

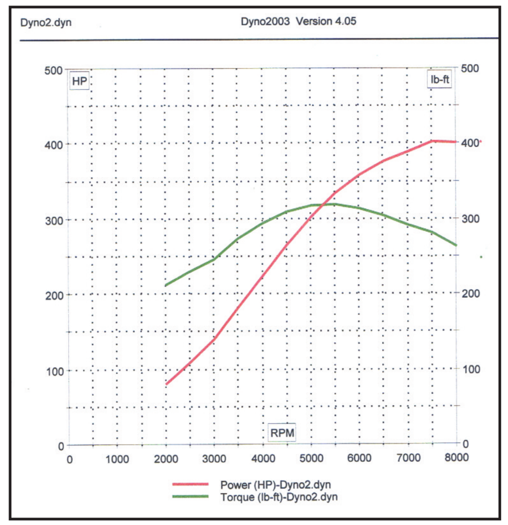
Cam Timing Summary:

Intake Centerline Angle: 108.0 — Exhaust Centerline Angle: 112.0

Lobe Centreline Angle: 110.0 — Valve Overlap: 65.0

Calculated Power & Engine Pressures

Engine RPM	Power (Fly)	Torque (Fly)	Int Man Pressure	Vol Eff %	BMEP Pressure
2000	81	213	14.70	66.2	152.4
2500	110	231	14.70	71.9	165.3
3000	141	246	14.69	76.1	176.6
3500	183	274	14.69	84.6	196.5
4000	224	294	14.69	90.9	210.7
4500	265	309	14.68	95.6	221.7
5000	302	318	14.67	98.9	227.6
5500	334	319	14.66	101.2	228.7
6000	358	314	14.65	101.6	224.7
6500	377	304	14.64	101.4	218.0
7000	389	292	14.64	100.8	209.1
7500	402	282	14.63	100.0	210.8



AJP/SPEED 6

Al Melling's original specification 3.5 litre AJP 24v 6 cylinder engine

The power graph and dyno figures I have produced for the 3.5 litre AJP engine are based on my discussions with Al Melling about the AJP6/Speed 6 engines and the original blue prints and specifications. To produce these I have used my Virtual dyno program which is very accurate providing you have the correct information (I have omitted certain parameters on cam timing etc as this is confidential information.)

Al Melling's original brief was to produce a 400 bhp straight six engine - as you can see from the figures I think he achieved this with his original design.