Chapter 3. 1960's / 70's competition versions

There were 4 major builders of modified Twincam race engines in the early 60's competition use of the twin cam engine and these were Cosworth, BRM who were the first building engines for Team Lotus cars, and they were followed by Vegantune and Hart from the later 60's. There was clearly a lot of sharing of knowledge among these builders as many of the people involved worked for the other companies over this period. E.g. Brian Hart worked at Cosworth during the racing twin cam development period before starting his own company and George Robinson worked at BRM before founding Vegantune.

There were numerous other smaller builders of modified engines and many of these people continued to build engines once the "factory" race engines were no longer being built. This was especially true in the US where SCCA Elans and Formula B continued to be popular and the Twincam was a competitive engine for many years. In addition, the growing historic racing movement worldwide continued to provide a demand for competition Twincams given the wide range of cars they were used in. People such as Ivey, Vegher and Dave Bean Engineering in the US and Holbay, Novamotor, and QED in the UK were building modified engines from the late 60's and 70's and on

Cosworth Mk12, Mk13, and Mk15

Cosworth appear to have been involved in the Twincam engine from the start of the Lotus race engine program during the cylinder head's prototype and development stage. This can be seen in the specifications for the Mk12 engine below which list only 4 bearings per cam which existed during the development stage, but which had changed to 5 bearings with the addition of a half width rear bearing in the production engines.

The Mk12 produced in 1963 engines had the standard ford crank and 116E rods so was limited to 6500 rpm with a dry sump lubrication system and ported cylinder head and something like a Cosworth L1 cam from the timing and lift specification. What exactly is a L1 cam is open to debate as lots of cam grinders have their version of what's called a L1, and they all differ a little.

The Mk13 produced in 1964 had a steel crank and stronger Cosworth rods and could rev higher and produced more power as a result

The Mk15 produced in 1965 came in both dry sump and wet sump versions.

MK 13; . 13-65 06-15

COSWORTH.

TWIN CAM ENGINE DETAILS (MK 12) ISSUE 2 - 12th March 197[illegible]

This engine is based on the 116E series Ford engine built by Lotus Cars Limited to their Elan production spec. It gives approximately 95 - 100 b.h.p. in standard form and this figure is increased to 140 b.h.p. minimum by Cosworth Engineering Limited when modified to series 12 specification. The serial number of these engines will start with 12 i.e. 12630105. It is essential to quote the engine number when requesting spares or information.

Overall Specification.

4 Cylinder capacity. 1594 c.c. (97.4 cu. ins.) Bore 83.5 mm (3.288")

Stroke 72.75 mm. (2.864").

	Compression ratio:	11:1
	Maximum b.h.p.	140 minimum @ 6,500 r.p.m.
	Maximum torque	125 lbs. ft. @ 5,000 r.p.m.
Cylinder Head:	Cast aluminium twin overhead camshaft. Hemispherical head. Valves set at included angle of 54°.	
Crank Case:	Monobloc type in cast iron - four cylinders in line bored at 3.2874" - 3.2884".	
Crankshaft Flywheel clutch:	Cast iron five main bearing crankshaft and flywheel, with Diaphragm type clutch on a light alloy mounting ring. Whole assembly dynamically balanced before assembly.	
Timing Cover Assembly:	Cast aluminium timing case and cover mounted on front of cylinder block enclosing Camshaft drive system by Renolds chain ½" pitch - chain tension controlled by spring loaded jockey pulley tensioner unit on one side of engine, rubber damper on opposite side. Timing chain also drives Jackshaft incorporating skew gear for distributor and oil pumps.	
Main and Big-End Bearings:	Vandervell Lead Indium Bearings. Steel backed.	
Pistons:	Special Racing Piston - with 2 dykes type compression rings and one oil control ring (split) Ring gap .019" Gudgeon pin 13/16" dia. retained by flat circlips.	
Valves: - Inlet	1.53 dia. - 5/16" stem. 45° seat angle. Material EN. 52.	

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TWIN CAM ENGINE DETAILS (MK 12)

Valves: - Exhaust 1.32" dia. - 5/16" stem. 45° seat angle. Material EN. 59.

Valve Springs: Special Cosworth racing springs to Cosworth spec. 116/35 Inner and 116/36 outer. New lengths. Outer 19/16" Inner 15/16" approx.

Valve Timing:

Inlet Valve opens	304°	46° B.T.D.C.	L 1 cams
" " closes		78° A.B.D.C.	
Exhaust " opens	304°	70° B.B.D.C.	
" " closes		54° A.T.D.C.	

Based on Tappet clearance of .010" NB. Correction for tappet clearance is .4° per .001" (crankshaft).

Camshaft Bearings: four pairs per shaft. Trimetal shells.

CAMSHAFT BRGS PL 3

INLET OPENS	52° BTDC	316	.007"	LIFT .433
" CLOSES	82° ABDC			
EXHAUST OPENS	71° BBDC	307	.009"	
" CLOSES	56° ATDC			

CARBS 33 mm 130 main 160 Air Corrector 50 F9 slow running 35 pump F11 Emulsion

Oil Filter: Externally mounted on chassis. Internal relief valve to be blanked off. NB. Standard oil filter on pump is not used. Special S.F.1. Felt Filter Element.

Ignition System: Coil ignition - Firing order 1342.
Centrifugal Ignition advance - 24° on crankshaft.
Vacuum advance - not operative.
Special Contact Breaker points, tension 28 - 32 oz.

Carburetters: 2 x 40 DCOE type Weber. Choke size 33 mm. Main Jets 130. Air Corrector jets 160. Slow running jets 50 F.9. Pump jets 35.

N.B. Jets are often changed during brake testing and may possibly be slightly different from above.

Water Pump: Driven from special steel crankshaft pulley of 3½ P.C.D. through corded vee-belt.

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TWIN CAM ENGINE DETAILS (MK 12)

RUNNING DATA

Oil Pressure:	60 – 70 p.s.i. 20 – 25 p.s.i.	running speeds. at tick over when hot.
Maximum Oil Temp:	110° C.	
Normal Oil Temp:	90° C.	
Optimum Water Temp:	70°C.	
Tappet Clearance:	.007" – .008" inlet	.008" – .009" exhaust.
Ignition Timing:	Set points just about to break with timing mark on front pulley opposite arrow on web of front timing cover. N.B. Ignition timing mark is on back flange of pulley only approx. 5/16" clockwise from T.D.C. mark on both flanges of pulley.	
Contact Breaker Gap:	.015" – .016"	
Recommended Oils:	Esso 40/50 or equivalent. Shell X100 Super M or equivalent.	
Fuel:	Esso Golden Extra or any other 100 octane (Minimum) fuel.	
Carburetter Flexible Mountings:	should not be overtightened. Spring washer should still retain some movement, even though rubber gaskets do not appear to be markedly squashed.	
Sparking Plugs:	Champion N55 T. Lodge RL. 49. KLG FE 290 or equivalent. N.B. MUST BE $\frac{3}{4}$ reach.	
Bolt tightening torque loads:	Cylinder Head Main Bearing Cap Big End Flywheel to Crank	50 – 55 lb. ft. 55 – 60 lb. ft. 23 – 25 lb. ft. 45 – 50 lb. ft.
Maximum Safe Revs:	7,000 r.p.m. 6,500 r.p.m. in first and second gears.	
Tacho Drive:	Rivetted to front cover by 2 x 3/16" counter sunk head rivets. N.B. Do not fit bolts or else the jack shaft bolts will foul them.	
Cylinder Head Refitting:	Great care must be taken to see that the cylinder head gasket is positioned on the cylinder block with the holes concentric with the cylinder bores. The best method of ensuring this is to make up two dummy dowels to suit two of the cylinder head bolt holes whilst fitting the head.	

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TWIN CAM ENGINE DETAILS (MK 12)

SUPPLEMENT TO ENGINE INFORMATION FOR COSWORTH MARK XII ENGINE

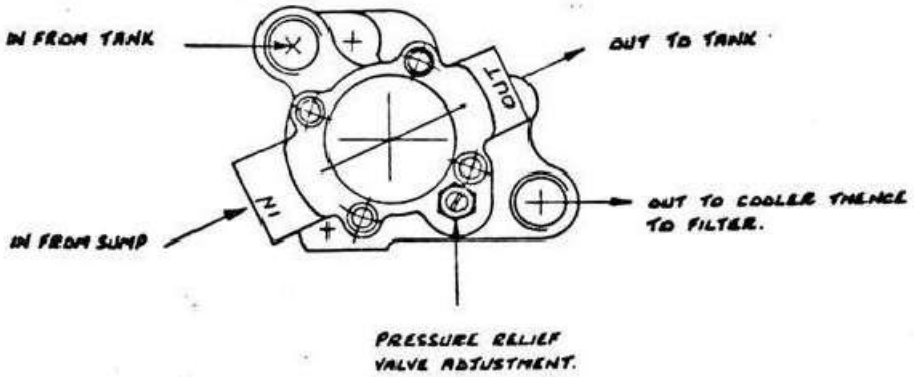
OIL PUMPS ASSEMBLY:

If the oil pumps assembly is for any reason dismantled, it is imperative that when re-assembled the shaft may be turned freely by hand before the unit is re-fitted to the engine. If this is not possible, then the driving gears will suffer, owing to the load placed on them. Any dirt which finds its way into the pumps will have a similar effect.

Providing these instructions are followed, the driving gears have proved to give no trouble at all.

ENGINES AFTER No. 12630210:

Engines including, and with later number than 12630210 are fitted with the latest oil pumps assembly. A sketch of the relevant oil connections follows:



DIAGRAMMATIC VIEW ON SIDE OF ENGINE

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TWIN CAM ENGINE DETAILS (MKS 13, 15 & S.15)

DRY SUMP ENGINE MARK 13: The Mark 12 engine has now been superseded by the Mark 13, the serial numbers will start with 13, i.e. 13630313. This new engine is different in that it is fitted with a later type of cylinder head, incorporating different valves and spring retainers, special connecting rods and special oil control rings. The fitting of the later connecting rods means that a block of a different height is now used.
The information amendment are as follows:-

PISTONS: Delete: "-with two dykes type compression rings and one oil control ring (split)"

Insert: "-with dykes type top compression ring, plain second compression ring and split type oil control ring fitted with expander"

BOLT TIGHTENING TORQUE LOADS:

Delete: Big end 23 - 25 lb. ft.
Insert: Big end 30 - 32 lbs. ft.

WET SUMP ENGINES MARK 15: The serial numbers of these engines will start with 15, i.e. 15630901. The information sheet amendments are as follows:-

LUBRICATION SYSTEM:
Delete paragraph, and ignore supplement
Insert: Wet sump fully pressurized system incorporating Hobourn-Eaton type pump with modified pressure relief valve spring and retainer.
Oil rooler outlets are provided by a sandwich casting fitted between the oil pump and the oil filter body.

OIL FILTER: Delete paragraph.
Insert: Mounted on oil pump body. Special S.F. 60 felt filter element.

OIL PRESSURE: Delete: 60 - 70 p.s.i. running speeds.
Insert: 55 - 60 p.s.i. running speeds.

BOLT TIGHTENING TORQUE LOADS.

Delete: Big end 23 - 25 lbs. ft.
Insert: Big end 30 - 32 lbs. ft.

ENGINE IS OTHERWISE AS MARK 13

WET SUMP ENGINE MARK S.15: Mark S.15 is similar to the Mark 15 in every respect except that standard Ford connecting rods are used instead of the special connecting rods. Bolt tightening torque load is 23 - 25 lbs. ft.

BRM Project 84 and 125 - Phase 1,2,3, and 4 tunes

Extract from a classic and sports car article

To commemorate 25 000 Lotus twin cams having been built by 1970 Lotus presented Walter Hayes of Ford with the 25 000th engine. Accordingly, MN (15-10-70) did an article on the engine. Relevant quotes from it include: "Owing to production difficulties Colin Chapman asked BRM if they would continue development on the racing version of the twin-cam for 1965, so Tony Rudd's team set to ... Bourne's dry-sumped products produced some 155-160 bhp and equipped with fuel-injection (as they were in the works cars) they found as much as 185 bhp." Another quote refers to the Elan-BRM marketed by Mike Spence: "Through BRM's involvement with the preparation with the racing twin-cam came a subsequent arrangement with Mike Spence at Maidenhead to market special Elans with BRM modified motors. The power units were sent to Bourne and completely dismantled and then rebuilt with different inlent valves, Cosworth CPL2 camshafts and ten thou and 20 thou respectively came off the head and block. The object was to increase the power of the LF/105 motor by about 20 per cent without any loss in flexibility or smoothness."

An advert by BRM referred to Twin Cam tuning from £485 - Stage 1 135 bhp, Stage 2 155 bhp, Stage 3 175 bhp and Stage 4 180 bhp plus.

From the above it looks like Chapman was getting impatient for the Mk13 engine development from Cosworth for 1965 and went to BRM to get an alternative developed and perhaps also to put some competition into development of factory race engines.

The horsepowers quoted above for the stage 1 and 2 engines look optimistic based on the cam details presented below but the data above may refer to Project 84 race engines not the Project 125 engines built for Mike Spence

Details of the project 125 Mike Spence Engines

The BRM Project 125, Phase 1 and 2 was what went into the Mike Spence BRM Elans. The CPL2 cam is the same profile as the “Sprint” cam used in later cars by Lotus

The slash at the end of the engine plaques below denotes the tune phase

Some more details on the BRM engines courtesy of Tim Wilkes:

It is important that we are not confused between the two BRM projects that focussed on the Lotus Twin Cam engine. The early Series 1 Elan 26Rs were fitted with BRM engines, tuned to their project number P84. The Spence Elan BRMs were fitted with engines tuned under project number P125. These two prefix numbers are therefore key differentiators when considering BRM engines in Elans. In the Spence BRM engine numbering system, 125 = BRM Project No P125, Mike Spence BRM Lotus TC Engine; 67 = Year, ie 1967; 001 = Engine number; /1 = Phase of tune, ie Phase 1.
Spence Elan BRMs retained the standard TC cam cover. The Spence Specification cars tended to have the crackle painted blaze orange BRM cam covers.
The Lotus SE Twin Cam was taken in exchange by BRM in Bourne. There it would be stripped down, 0.010" taken off the cylinder head face, both inlet and exhaust ports modified and polished to increase airflow, whilst the inlet valves were replaced with BRM items of 1.55" diameter. Two camshafts could be installed. The Phase 2 had the CPL2 (26/66/66/26) cam which gave 125 - 129bhp. The Phase 3 had the L1 cam, which turned out a good 140bhp. Phase 1 engines retained the SE C Lotus type cams. Meanwhile the cylinder block had 0.020" machined off its top, giving a 0.014" squish deck height to the piston, the block was also trued to give as perfect a seal between it and the head as could be achieved. The flywheel and clutch assembly were double dowelled to maintain constant union. The crankshaft was dynamically balanced. The standard C type con rods and pistons were retained and balanced to very fine tolerances. The oil pressure relief valve was swapped for a stronger one, which gave 55 to 65 psi at working speed, helping to maintain good lubrication. On the intake side the standard Weber 40 DCOE units were retained, though 33mm chokes and 130 main and 170 air correction jets fitted (Phase 1 used 30mm choke, 115 main & 200 air). On the other side of the bay the exhaust system was replaced with a fabricated four branch manifold of larger diameter. A straight through silencer, sourced from the Jaguar E Type, could be specified. After meticulous assembly, each engine was bench tested at BRM's Folkingham airfield test shed. If an engine was outside a 2.5bhp allowance, it was failed. Most Phase 2 engines turned out 125-127bhp on the bench. A Taurus thermostatically controlled oil cooler could be specified if required

Some more details of the Project 84 race engines (its not clear what state of tune, but this is clearly an early engine in the race engine program based on its specifications)

TYPE 84 ENGINE INFORMATION FOR THE RUBERY OWEN MODIFIED FORD LOTUS CORTINA ENGINES & 26R S2:

In standard form the engine gives approximately 105 bhp, but when modified by the BRM Engine Development Division of Rubery Owen & Co. Ltd. Gives a minimum of 145 bhp. It is vital that the engine number is quoted when ordering spares.

OVERALL SPECIFICATION
Capacity: 1594 cc (97.4 cu. In)
Bore: 83.5mm (3.288")
Stroke: 72.55mm (2.864")
Compression ratio: 11:1
Maximum bhp: 145 minimum at 6,750 rpm
Maximum torque: 130 lbs. Ft. at 5,000 rpm
Maximum BMBP 201 psi at 5,000 rpm
Maximum rpm 7,000 rpm
CYLINDER HEAD
Cast aluminum twin overhead camshaft hemispherical head. Valves set at included angle of 54°
CRANKSHAFT / FLYWHEEL CLUTCH
Cast iron crankshaft and flywheel with diaphragm type clutch. Whole assembly dynamically balanced before assembly.
TIMING COVER ASSEMBLY
Cast aluminum timing case and cover mounted on front of the cylinder block enclosing camshaft drive system by Renolts Chain 3/8" pitch, chain tension controlled by spring loaded jockey pulley tensioner unit on one side of engine and rubber damper on opposite side. Timing chain also drives jackshaft incorporating skew gear for distributor and oil pumps.
MAIN AND BIG END BEARINGS
Vanderwell lead Indium bearings. Steel backed.
PISTONS AND CON RODS
Die cast piston with Ford steel conn rod (125B) two plain compression rings and one four piece steel oil control. Ring diametral clearance of skirt 0.006" – 0.008". Ring gaps 0.016 / 0.021.
VALVES
Inlet 1.53" dia. – 5/16" stem 45° seat angle mat: - EN52
Exhaust 1.32" dia. – 5/16" stem 45° seat angle mat: EN59
VALVE SPRINGS
Special BRM racing springs to BRM specification. A.7005 Inner and A.7004 outer. Free lengths 1.426" inner; 1.400" outer.
VALVE TIMING
Inlet valve opens 54° BTDC
Inlet valve closes 82° ABDC
Exhaust valve opens 72° BBDC
Exhaust valve closes 54° ATDC
Based on tappet clearances of 0.009" exhaust 0.006" inlet and using 0.002" shim foil for timing (see over).
LUBRICATION SYSTEM
Wet sump engine with standard Ford oil pump and filter but fitted with high rate oil pressure relief valve spring.
IGNITION SYSTEM

Coil ignition, firing order: 1 3 4 2
Centrifugal ignition advance, giving 24° crankshaft advance
Standard contact breaker points 18 – 24 oz. Spring.
Static ignition setting 14° BTDC
Contact breaker gap 0.012"
(Static timing may be changed during dynamometer running)
MAXIMUM SAFE REVS
7,000 r.p.m.
6,500 r.p.m. in first and second
FUEL SYSTEM
Supply drawn from Bendix high pressure type 12 volt pump.
If it is ever necessary to replace the clutch pressure plate assembly, the new one must be balanced on the crankshaft / flywheel assembly and marked to ensure correct refitting thereafter.

Its not clear what state of tune in terms of the Phase 1 to 4 terminology used by BRM applies to this specification sheet , but this is clearly an early engine in the race engine program based on its specifications. The low rev limit is consistent with the use of standard cast iron crank and cast pistons.

The long duration 306 degrees cam is typical of racing cams in the period and really a waste of time with the 7000 rpm rev limits in my opinion. I suspect the 82 degree ABDC quoted is a typo and they meant 72 Degrees to give the same timing as the exhaust

The reference to the use of a Ford 125B rod may be a typo or perhaps this was a predecessor to what appears as the 125E rod in later standard Mk2 engines