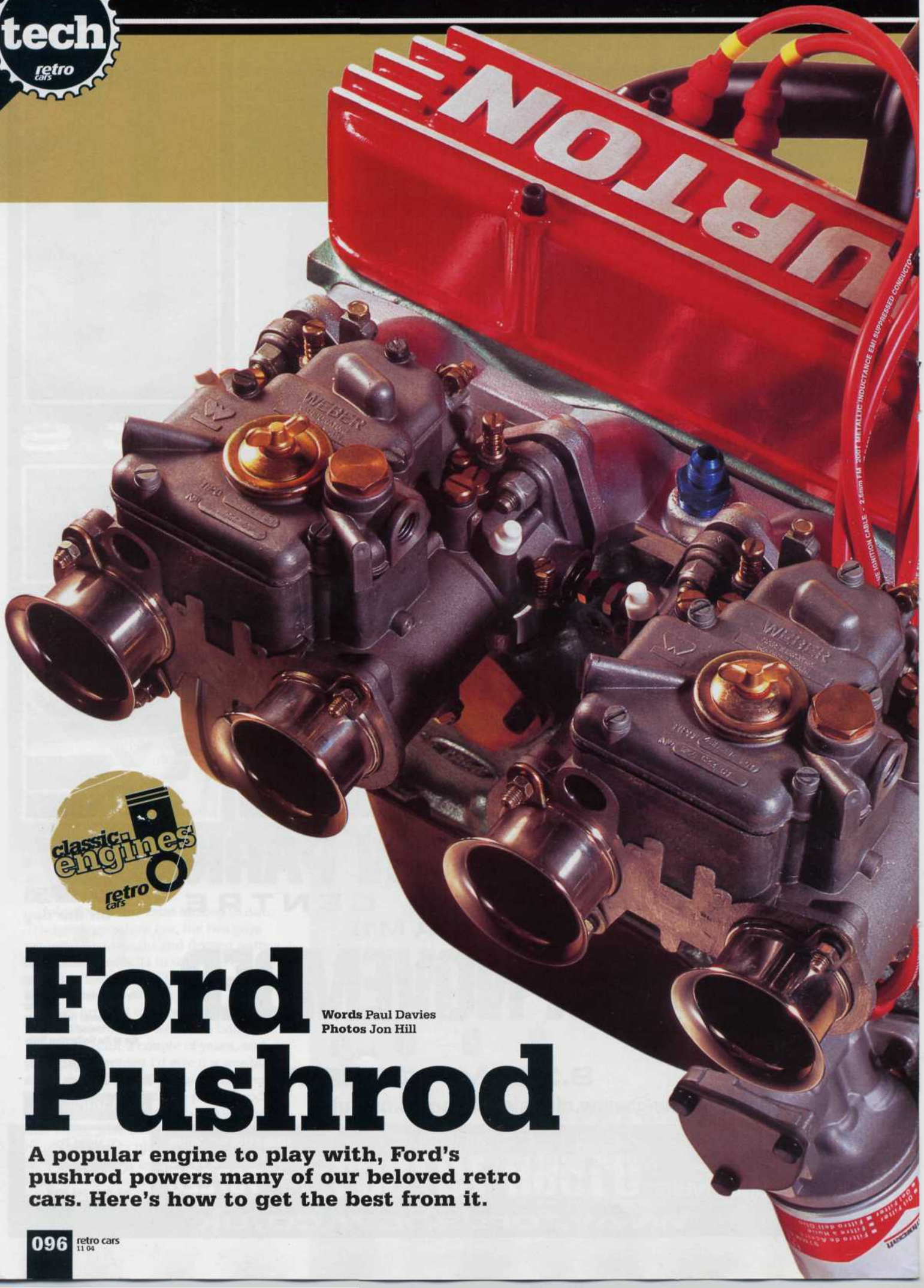

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Ford Pushrod

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A popular engine to play with, Ford's pushrod powers many of our beloved retro cars. Here's how to get the best from it.

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In the near future retro-kids will ask about the facts of life. "Daddy what's a pushrod?" the miniature enthusiast will question. Born in a world of overhead camshafts, multi-valve cylinder heads and engine management systems, the mere idea of operating the valves through long sticks, pushed up and down by a single shaft buried deep in the engine, will seem just crazy.

Retro-dad will sigh, put down his copy of *Classic Anorak* magazine, and begin. The BMC A-Series engine will be dismissed in a few words as "so 1950s" and then he'll go dewy-eyed as he tells the story about Ford's great range of four-cylinder pushrod motors. Generations of classic car enthusiasts, he'll say, owe it all to a dynasty produced from the late '50s through to the turn of the last century.

Without these the Anglia, Cortina, Escort and others — not to mention such famous names as Cosworth, Holbay, Stewart, Clark (J and R) and Senna — might not have happened.

Yes it's old technology now, but the Ford fours can lay claim to being at the centre of the formative years of the classic car. And, more to the point, they're still out there in hundreds of thousands — waiting to be lovingly rebuilt and modified.

Pushrod Fords slip comfortably into two sections: Kent crossflow engines and the earlier pre-crossflow units. And it all began in 1959.

Ford's first small overhead valve engine appeared in the radical, reverse-slope rear-window Anglia 105E and at almost the same time was slotted into the older style, four-door Prefect 107E. With cast iron block and cylinder head, and the inlet and exhaust ports on the same side as the cylinder head it wasn't revolutionary. But with 997cc developing 39 bhp it had the ability to rev well and it wasn't long before Formula 3 versions were producing over 100 bhp at 9000 rpm.

By simply lengthening the stroke — changing the crankshaft and connecting rods — the engine grew to 1340cc for the first Classic and then an in-between 1198cc version powered the Anglia Super and the first Cortina.

Ford, however, recognised the limitations of the three bearing crankshaft. In 1962 it produced a 1498cc engine with five bearings, which ultimately gave us the Mkl Cortina GT and, with a radical head change, the all-conquering Lotus Twin Cam. A 1297cc five bearing motor was also produced for the Cortina.

It was all-change in 1968. The Kent series appeared with crossflow cylinder heads (the inlet and exhaust ports on separate sides) and the combustion chamber built into the piston crown. With capacities from 940cc through 1098cc, 1298cc to 1599cc the engine powered Cortina and Escort models and in 1600 GT form became the basis for the world's most successful racing formula — Formula Ford.

We know it best for its place in the Escort Mexico, and as the basis for the 16-valve Cosworth BDA. The motor's final UK appearance — in altered transverse form — was in the first Fiesta XR2, but production continued in South Africa until just a few years ago.

Almost every engine hop-up merchant you can think of has got his hands on the Ford four at some time. Many have come and gone, but Burton Power has been with the engine right from the beginning and is still there, in Ilford (where London meets Essex), with an unparalleled mix of experience and the right bits. Naturally we thought it only right to visit them for the facts. Besides, Barry Lee, and crew, would probably never speak to us again if we went elsewhere.

Nowadays a Ford Zetec or a Vauxhall XE may well appear to be the obvious choice for a upgrade in an Escort or kit car, but don't dismiss the original power plant. There's life in the old dog yet and the next few pages will tell you how to keep this one barking.

Block And Internals

The ingenious idea Ford had was to fix the bore size at 80.97 mm and get the capacity changes from varying the crankshaft, connecting rods and pistons. Except that doesn't mean all four-cylinder blocks are the same: early engines had three-bearing crankshafts before the stronger five-bearing units became universal (see our facts table) and larger capacity engines necessitated a taller block to accommodate the longer-throw crank. It's best to split the various units into pre-crossflow and Kent series crossflow engines.

Pre-Crossflow

Early three-bearing units (997cc, 1198cc and 1340cc) had hollow crankshafts and while the first two engines are pretty robust the 1340 — like the Classic that came with it — is severely limited on revs. From 1962 all three engines standardised on a revised 109E (Classic) block with solid crankshaft, while the 1498cc block, introduced in 1963 with five bearing crank, was 0.67 inch taller.

A later development of this block (with revised rear main bearing seal, larger big end retaining bolts and a diaphragm clutch flywheel with six fixing bolts instead of four) had a slightly stiffer casting and was used in the MkII Cortina 1300, as well as later 1500 and 1500GT engines.

It's possible to alter the capacity of the three-bearing crankshaft unit by swapping crank, rods and pistons. However, care must be taken to ensure the resulting compression ratio is still workable. Retaining the existing head and fitting a 1200 crank/rod conversion in a 997 block will bring the CR up to a useful 9.5:1 (from 8.9:1), but a 1340cc conversion will need the combustion chambers opened out to achieve a lower figure.

While a straight capacity increase will bring a little more power and torque, a swap to a 1500 or 1600 motor is preferable. The 1340cc engine must, anyway, be limited to around 5500 rpm.

Further modifications and tuning of the pre-crossflow engines follow the same pattern as for the crossflow units and most of the equipment now available is for the later engine.

Stock crossflow pistons (above) are suitable for up to 7000 rpm. Beyond that forged Accralite items (below) are the best bet.

Ideally a steel front pulley needs to be fitted to the high revving Crossflows as the stock item is a lot weaker and can shatter.

Burton's light-weight steel flywheel weighs in at just 5.9 kg.

Kent Crossflow

The bores remained at the ubiquitous 80.97 mm dimension and the varying capacities were obtained by stroking. The 1600 block — with the number 681F stamped on the side — was 1.1 inches taller than the original 997 three-bearing unit. Introduced in September 1967, the Kent engines underwent one major block change in 1970, when uprated versions were announced.

The later block — with 711M marking — has a stiffer crankcase, strengthened mains bearing caps, larger diameter cam followers (13 mm instead of 11 mm) and a modified crankshaft end seal and is obviously ideal if tuning is planned.

There is one other Kent block, the AX unit manufactured in South Africa. A version of the 711M-type, this was a new thick wall casting that made greater over-bores possible and, because of its strength, was much sought after by Formula Ford competitors. Production of this (with AX on the side) ceased just three years ago.

The 1600 block, especially in 711M form with stronger (flat) main bearing caps is good and strong with standard crank, rods and pistons that will handle up to 7500 rpm. With heavy duty connecting rod bolts 8000 rpm is possible. The best combination — without going to specialist steel competition rods — is to use Ford's 2737E rods and bolts. Beyond this figure the standard cast pistons, with a slot behind the bottom oil control ring, are the weak link.

The Kent piston which contains most, if not all, of the combustion chamber is a meaty item, which has to deal with a lot of heat transference and, because of its weight, is limited on ultimate rpm. Burton advises fitting Accralite forged pistons for high performance engines. These are available in a large number of sizes which, block willing, can take a 1600 unit out to over 1800cc.

Normal 711M blocks will usually bore to 83.5 mm which, with standard crankshaft dimensions, gives 1699cc and an 84.0 mm bore (1720cc) is often possible. The much talked about 85.0 mm piston size (1760cc) is borderline on many blocks, while 86.5 mm (1824cc) is reserved for the old South African AX engine or Burton's own product.

With good quality Kent blocks now becoming less available, Burton has had its own cast, in both aluminium alloy (light weight, good

Farndon produced steel con-rods are one of the best options for use with with uprated forged pistons.

The later 711M Crossflow block is the best of the bunch to use. Look out for a new Burton Power produced alloy version soon.

heat transference and the ability to easily off-set bores for greater capacities with 90 mm bore) and iron. These are made in both short (Lotus Twin Cam and 1500 pre-crossflow) and tall (711M) sizes.

Burton can also supply Farndon-manufactured steel crankshafts for the Kent engine, made with standard width big end bearings (26.85 mm) or with narrow bearings (23.7 mm) to reduce friction. Appropriate width (Farndon) con rods are required for the latter.

Two points concerning original manufacture are worthwhile mentioning. Quite a few engines seem to have left Ford fitted with oversize mains shell bearings, presumably because the blocks have been line bored to rectify errors in alignment. If you don't spot this when carrying out a rebuild and fit standard size bearings, oil pressure will be depressingly low. Burton has had + 0.015 inch shells made to cover this eventuality.

Secondly, the manufacturing threw up some blocks that were not accurately cast and (very) thin liners were fitted to allow a re-bore. These will not stand a further re-bore and are suitable only for scrap.

Cylinder Head

Pre-Crossflow

Heads will benefit from the usual modifications to the ports and opening out of the combustion chamber around the valves. However, this will almost certainly have to be carried out on a customer's supplied head, as they don't pop up on parts shelves very often these days.

The heads on all three bearing engines had the same size valves (1.27 inch inlet/1.18 inch exhaust) while the 1297cc and 1498cc five bearing motors had 1.43 inch inlet/1.18 inch exhausts. 1500 GT heads had 1.41 inch inlets and 1.245 inch exhaust and these can be used to good effect in the smaller capacity heads.

Compression ratios can be raised by machining up to 0.080 inches from the head face and with the three-bearing engines it's possible to swap around. A 997cc head on a 1200 motor ups the CR to around 10:1 and a 1200 head on a 1340 has the same sort of effect.

Kent Crossflow

The design is considerably more efficient than the earlier head, but also benefits greatly from gas flowing of the ports. While it is true to say that in all engines most (or all) of the combustion chamber is contained within the bowl in the crown of the piston, it's not quite that simple.

Late (711M) crossflows had totally flat cylinder heads and combustion chambers in the piston crown.

This pre-crossflow cylinder head shows both inlet and exhaust ports on one side and has full-size combustion chambers.

The early (681F) crossflow 1.6 engines had shallow combustion chambers in the head and the rest were in the piston crown. The 1.1 and 1.3 units had flat heads.

Early (681F block) 1098cc and 58 bhp 1297cc engines had completely flat heads, but the 1300GT and the 1600/1600GT units had a partial recess in the head as well as the bowl-in-piston combustion chamber. All post-1970 engines had totally flat heads and bowl-in-piston combustion chambers.

Although the ports can be reshaped very little modification can be done to the recess-in-head chambers — the best heads to work on are the totally flat ones.

One handy low cost conversion for 1600 engines is to fit 1300 pistons and rods, which will give a useful hike from 9.0:1 to 10.3:1. In this case it's essential to check there is sufficient cut-out in the piston crown for the valves if a high-lift cam is being used.

The two lower powered Kent engines (1098cc and 1297cc non-GT) had heads with 1.41 inch inlet and 1.24 inch exhaust valves but the 1300 GT and both 1600 motors had inlets increased to 1.5 inch diameter.

Note also, valves fitted in heads with recesses were shorter than on flat heads. Whilst the 1.5 inlets are of reasonable size for a mildly tuned engine, you will need to go to 1.625 inch inlets for a fast road engine, but the GT exhausts are adequate at this stage. Race engines will use 1.8 inch inlet valves and exhausts of 1.5 inch.

Early Kent engines had valves with 9/32 inch diameter stems, while the post-1970 uprated version had 5/16 inch stems.

Although Burton considers bronze valve guides as essential for a race engine, it advises against them for road use. They need greater lubrication so it's necessary to dispense with the valve stem seals, resulting in oil smoke.

Both the Kent and pre-crossflow heads need hardened exhaust valve seats to run on unleaded without valve seat recession.

Burton has also had its own flat-top alloy cylinder heads manufactured for these engines.

Lubrication

High capacity/high pressure oil pump is a direct replacement for the standard part and is essential for fast road use. A baffled sump will also be needed.

No major problems here as long as the block is in good condition with oilways cleaned out. There should be around 30 psi on the gauge on tick-over and 45 to 50 psi at 4000 rpm. An oil cooler is often necessary and, to avoid a pressure drop when this is used, an uprated pump should be fitted.

The four-cylinder Ford engine is a classic case for baffling. If you are staying with the standard item (ie not going to a full dry sump kit, which is certainly preferable on race engine), then any amount of hard cornering will result in oil surge. This could, in the worst case, cause the inability for the pump to pick up lubricant. Strategically placed baffling will prevent this.

If you are fitting an engine that was original equipment in another vehicle, check the shape of the sump. Depending upon crossmember location, the deep part of the sump may be at the front or the back and whatever you have has to be compatible. Don't forget dipstick location (front or back?) if you're swapping pans around.

Fitting a dry sump kit will eliminate oil surge and improve flow in competition engines. A remote oil tank will also need to be fitted.

Camshaft And Valve Gear

The single camshaft is mounted in the block and driven by tensioned chain from the crankshaft. The valves are operated by pushrods acting on rockers on a steel shaft.

Ford made very few cam changes through the life of both the Kent and pre-crossflow motors. Apart from the earliest 997cc units, the same cam was used in all non-GT engines up to 1971 model year, when the uprated Kent engines were introduced and camshafts had wider lobes. The diameter of the cam followers was also increased.

There have been many classic cam profiles for the engine, Cosworth's A-Series being perhaps the best known. Although these are no longer available, cam specialists have developed new and more advanced designs, many based on well proven originals. Burton's own designs, many originally produced by veteran Ford specialist John Liveseley, are made by Kent Cams.

Although many cams are available, the choice of rocker gear is limited. Burton can supply new rocker posts and shafts, but original Ford rocker arms are no longer available. However, roller rockers are, but these are quite expensive and a bit of an overkill for a road car.

You can get replacement steel rocker posts and shaft but only roller-rockers are currently available.

Pre-crossflow and 681F blocks are fitted with narrow diameter tappet stems, raised from 9/32 inch to 5/16 inch with the 711M block.

Induction

A pair of 40 or 45 DCOE Webers is hard to beat on any of the Ford pushrod engines.

Ultimate power and improved flexibility will come with throttle bodies and appropriate electronic management system on a full race engine.

These Ford motors were around long before the electronic age. Original engines utilised either Zenith, Solex or GPD (Ford's version of the previous two) downdraught instruments. This was with the famous exception of the 1500 GT, which was fitted with one of the most marvellous retro carbs seen to man — the legendary, progressive choke, Weber 28/36 DCD.

With two-stage operation the precision built Weber provided economy and torque at low throttle openings and then, as the secondary choke came in, worked like twin carbs. Often copied (anyone heard of the Nikki carb?) it was never beaten, but when the Kent 1600GT came along Ford got Weber to make them a special version, the 32 DFM, with — non changeable — chokes cast into the body. It did the job for Ford, but could not be easily re-choked and jetted to match varying stages of tune like the 28/36 DCD.

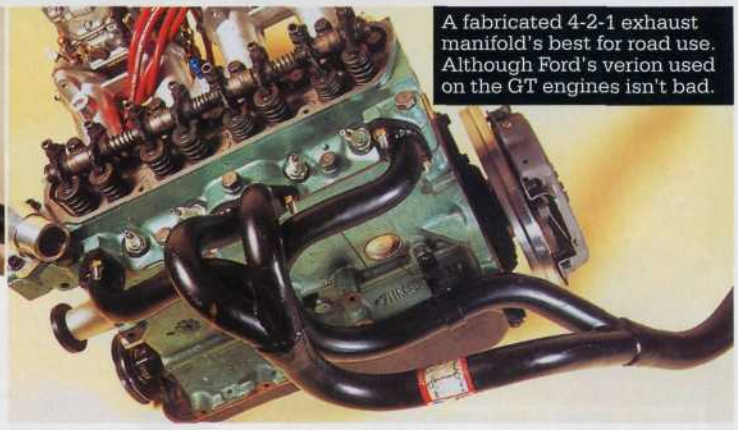
Nowadays, neither the DCD or DFM is being manufactured, but if you're looking for an economical induction upgrade for a mildly tuned four-cylinder Ford you should consider the (still very much in production) Weber DGV, as fitted to late-model Escort Mexico and the Essex V6-engined Capris.

But if you're totally serious, there's only one way to go. Once again put your hands together once again for Weber 40 DCOE or 45 DCOE depending upon state of tune. A pair of these beauties work wonders on almost every engine, Kent crossflows included.

The twin sidedraught Weber set-up will take a Kent engine up close to the 200 bhp mark. To go higher than that a new set of throttle bodies and an appropriate engine management system is important and is, for best running, the only way to go.

Exhaust Manifold

With four exhaust ports, the 4-2-1 manifold works well on a road tune engine, while a 4-1 system will show top end gains on a fully tuned racing unit. Lowly production engines had cast iron manifolds, but GT engines had a fairly efficient 4-2-1 tubular system as standard. Ashley Competition Exhausts manufactures a 1500 manifold, which is available from Burton Power.



A fabricated 4-2-1 exhaust manifold's best for road use. Although Ford's verion used on the GT engines isn't bad.

How Much?

Stage 3 modified cylinder head	£558
Set Accralite 83.5 mm forged pistons	£500
High pressure/high capacity oil pump	£65
Inlet manifold for Weber DCOE carbs	£85
A6 profile camshaft	£100
Steel flywheel, 6 bolt fixing (5.9 kg)	£135
Steel mains bearing caps (set of 5)	£100
Burton alloy cylinder head	£882

All prices inc VAT from Burton Power for Kent 1600 engine.

Source

Burton Power
617-631 Eastern Avenue, Ilford, Essex IG2 6PN
020 8554 2281

How Much Power Can You Get?

Fast Road Tune

Stage 3 head, ported and gas-flowed with 1.625 inch (41.3 mm) inlet and 1.24 inch (31.4 mm) exhaust valves, two-angle valve seats, double valve springs and new iron guides, Kent 224 (270 degree duration/10.6 mm lift) camshaft, 2 x Weber 40 DCOE carbs — 120 bhp at 6500 rpm.

As above, with:

Kent 244 camshaft (290 degrees/11.3 mm lift) — 130 bhp at 6500 rpm.

Club Competition Tune

Race cylinder head, further modified with 1.375 inch/34.9 mm exhaust valves and bronze valve guides, Accralite 10.5:1 forged pistons (standard rods, crank and mains caps), Kent 244 cam, 2 x Weber 45 DCOE carbs — 140 bhp at 7500 rpm.

Race Tune

Further modified head, with 1.8 inch/45.5 mm inlet and 1.50 inch/38.1 mm exhaust valves, all-steel crank, rods and Accralite pistons, A6 camshaft (336 degrees duration/10.2 mm lift), 2xWeber 45 DCOE carbs, steel flywheel, dry sump kit — 170 bhp at 8500 rpm.

All above figures from Burton Power on Kent 1600 engine.

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Ford Pushrod Engines: The Facts

Block: Cast iron with three or five mains bearings.
Cylinder head: Cast iron, four inlet/four exhaust ports. Crossflow, with bowl-in-piston combustion chamber with Kent series engines from 1968.
Camshaft: Single, block mounted, chain driven and operating overhead valves through pushrods.
Induction: Downdraught carburation, Solex, Zenith or GPD (Ford) with single, dual progressive choke, Weber on GT models.

Year	Capacity	Bore/Stroke	Induction	Power	Cars
Pre-crossflow (three-bearing crankshaft)					
1959	997cc	80.97x48.4 mm	Solex or GPD	39 bhp	Anglia
1962	1198cc	80.97x58.16 mm	Solex	48 bhp	Anglia Super/Cortina 1200
1961	1340cc	80.97x65.08 mm	Zenith	54 bhp	Classic/Classic Capri
Pre-crossflow (five bearing crankshaft)					
1966	1297cc	80.97x62.9 mm	GPD	54 bhp	Cortina MkII 1300
1963	1498cc	80.97x72.75 mm	Zenith	59.5 bhp	Classic 1500/Cortina 1500/Corsair
1963	1498cc	80.97x72.75 mm	Weber 28/36 DCD	78 bhp	Cortina 1500 GT (MkI & II) Classic Capri GT/Corsair GT
Kent crossflow (five bearing crankshaft)					
1968	1098cc	80.97x53.29 mm	GPD	53 bhp	Escort 1100
1968	1297cc	80.97x62.9 mm	GPD	58 bhp	Escort 1300/Cortina MkII/Capri MkII
1968	1297cc	80.97x62.9 mm	Weber 32 DFE	75 bhp	Escort GT/Capri GT
1968	1599cc	80.97x77.62 mm	GPD	71 bhp	Cortina MkII/Capri 1600
1968	1599cc	80.97x77.62 mm	Weber 32 DFM	88 bhp	Cortina GT/Capri GT

GT engines also featured larger valves, uprated camshaft and four branch exhaust manifold.
NB: Early MkII Cortinas ('66-'68) were fitted with pre-crossflow engines.