Building a Reliable Spitfire Engine for High Performance v1.4

Written by Calum E. Douglas

Hosted & Formatted by Jeff McNeal for
the Totally Triumph Network
Original posting date: March 26, 2001

Quick reference index:

Foreword:

A great deal of confusion seems to rest in how to modify your Spit engine for more power (especially how to do it with reliability). During the past two years of having my Spitfire I have spent much time collating all the information I could about Spitfire engines and high performance engine building in general as the subject fascinates me.
Of course much of the information I got was contradictory or even occasionally total rubbish so the final balance is of common sense combined with good general engine knowledge. I have tried to avoid including information that I was not able to corroborate for accuracy with a second source.

The spec of my engine is near the end of this guide so you can see exactly what I have done first hand. Unfortunately I have not the money or experience to have done ALL of the operations described in this text; so for those bits of information I have not personally tested I've made as sure as possible that they are accurate. Also included are several unusual items which I have not been able to verify for worth, all these are clearly marked as such so that you can tell what you might have to do further research on before trying.

I am deeply indebted to those few Triumph gurus who helped me separate gold dust from dirt, most notably Terry Hurrell at the helm of Triumph Tune.
All the advice I got was genuine and obligation free, that in itself is unusual these days.

I have written this as I got fed up seeing people (not necessarily at TTG) telling others that all they had to do was whack the compression up to 12/1 and fit 4-1 headers. I hope that this may dispel some of these (and other) old tales about tuning.

The following is my best understanding of Spitfire engine tuning and for the most part should obviously not be regarded as the opinion of a professional engine builder. Feel free to strongly disagree with any of the points I make and if you choose to explore in practise any of the following always seek professional advise from the engineering shop you employ before embarking on any expensive operations.
I have written this as a bona fide Triumph and performance engine fanatic attempting to make the maze of engine modification a little simpler, so please do not e-mail me angrily with stories of how your engine blew up after you tried these ideas. It is up to you to decide what to do and this information is meant as a guide not a bible. I refuse to accept any responsibility for adverse consequences arising from the use of this text.

It is my honest belief however, that when followed correctly this guide will allow you to build yourself or have built a very dependable and exciting Spitfire engine.

As a help I have included all the books I have read to obtain much of this information, not all of it was gained from books of course but I can't be giving out everyone's phone numbers. There are those who work for relavant companies you <u>can</u> phone up. Their names are in the Bibliography.

Considering this as a definitive guide would be an act of very sad self worship on my part and there is much useful information that I am not aware of, if you know some of it please tell me!

The Golden Rule For Engine Rebuilding

I read this and it seems to me to be perfect, when building an engine assume NOTHING. Double and triple check everything, all measurements and dimensions. Do not assume that any factory produced item is accurate, "***always check everything*". **

Remember too that Sods Law is always hard at work and likes nothing more than groundless (and possibly very expensive) assumptions on your part. Be sure to avoid Sod by following the `Golden Rule`.

Introduction:

It is my opinion that intrinsically most Triumph engines were reasonably sound in design, it is also my opinion that they were not put together very well or machined to very fine tolerances.

If built well and looked after there is no reason why they cannot be perfectly reliable and at the same time more powerful than they left the factory.

The Triumph Stag is a very good example, most "down the pub" talk will state that it had a terrible engine that was good for nothing but overheating and blowing head gaskets. Indeed it did do that but only because it had aluminium cylinder heads, the dealers forgot to tell every one to put 1/3 antifreeze in all year round to stop the heads corroding.
The heads corroded clogging the radiator with silt, then the block overheats and a gasket blows, new gasket and a month later it blows again. It would have been fine if it had been looked after properly. The same goes for your Triumph Spitfire engine.

As a rough guide I have included a price in GBP for most operations and tools. These prices are obviously just approximate and depend on which country you live in. They should give you a ballpark figure to work with.

Shopping For Performance Parts:

I felt this to be an important section, looking at various parts suppliers (most notably ones in the USA) it is quite shocking the utterly absurd prices they get away with charging. There are three US based companies who are classic or Spitfire specialists who are particularly expensive. I shall not mention their names, their absence from my recommended suppliers list should suffice.

Examples: ....Best price..... Typical Rip Off Prices

Weber DCOE Carb.....................................£217...................£250>£350

Aldon UK Performance Distributor.......... £120.................. £180

Weber Inlet Manifold ....£80 ....£150

Fast Road Camshaft ....£70 ....£170

Vernier Cam Timing Chain & Gears..........£120 ....£180

These are prices I have just got off the Internet today. For machining work you should pay extra to use a really good firm but for standard off the shelf parts like these it really does pay to shop around. Suppliers in the UK will usually be the cheapest. The bigger ones such as those who make all of the above in Britain will happily ship all over the world for reasonable rates.

For all such things as ARP Fasteners, K&N Air Filters, Carbs, Heat Wrap, Alloy Radiators, Oil Coolers you should buy from one of the very big generic Motorsport supply companies and not a small classic car specialists. The price difference can be very substantial.
Examples of these bigger companies are RALLY DESIGN, DEMON TWEEKS & MERLIN MOTORSPORT.

I know that might seem slightly short sighted as I do like to support small companies who help to keep our cars going.

For non Spitfire specific products these small suppliers stock they do have to get their act together.
I can't go around bankrupting myself just to keep the local Spit parts supplier in business. Weber carbs are a good example, they are not for Spitfires specifically & are not made by anyone except Weber themselves. What excuse any company can have for selling them at 30% more than normal market price is beyond me. They are ready jetted and set up for Spits but any Weber distributor will do this free of charge if you supply the spec you require.

Most of this stuff is manufactured in Britain so purchasing from there makes more sense. Remember that those buying from outside the EU pay no VAT which is 17.5%. A very useful saving.

Which Engine Should I Choose?

I enter this debate with much trepidation, few Triumph subjects are as heated and varied as to which engine is best. After reading every single bit of Triumph literature I could get my hands on and many telephone calls to those who have raced & modified Spits almost since before I was born (no really!), I can with reasonable certainty give a good account as to which engine is best for which purpose.

Here is a small list of the usual reasons you hear for choosing various engines and a short explanation of each. A rev limit for each is provided as it seems to be a much requested figure. These are limits which relate to avoiding mechanical failure NOT avoiding high wear rates so its still not terribly clever to sit on a motorway at 5500 Rpm all day.

- Cam Bearings: The cam only travels at HALF crankshaft Rpm, wear will not be a problem unless racing. Any good engine outfit can machine your block to have cam bearings installed for around £90.

- Block bore recess: A recessed ring around the top of the bores, provides a better head seal. Again the early engines have no particular problem with blowing head gaskets so probably of limited value unless running a high compression race engine.
As before it is perfectly possible to machine a flat top block to have these, if you do so you must then use the later head gasket too. It has a quite visible enlarged ring around the bores. Check for this on your gaskets as I

was once supplied a flat gasket for a recessed block.

- Post 1973 Spits had bigger valve heads which are capable of flowing slightly more air, if you get the engine properly modified you will be replacing the valves and fitting bigger ones anyway. As far as bolt on swaps go this is useful though. Beware that 1500 and 1300 heads do not swap, the combustion chamber size is different.

- Short stroke vs long stroke: The 1147 & 1300s can all rev much higher than a 1500, the 1500 due to its bigger capacity has more low down pulling Torque. If you build a 1500 properly and respect it then this much maligned engine can be as dependable as any other Spitfire engine.

<u>The Early 1147cc Mks 1&2 Engine: 6000 Rpm Standard, 9000 Rpm full race</u>

The 1147cc engine is obviously rare and so far fewer tuning bits are available for it, its reliable and took the Le Mans Spitfires to a creditable 134 Mph with over 100 Bhp from the tiny engine.
The car completed the 24 hours at an average speed of 94.7 Mph. For this purpose special 8 port aluminium cylinder heads were cast, if you can find a genuine one of these you are a lucky chap! To the best of my knowledge there are no reliability problems with this engine.

A high revving engine, lower Torque and Bhp than 1300 or 1500.

<u>The 1296cc Mk3 Engine: 6000 Rpm Standard, 9000 Rpm full race</u>

This is usually the first choice for the full race brigade. It has the lightest internals, the camshaft runs in bearings and still a short stroke. Perfect for spending some time at 9000 Rpm.

Note that the Herald version does NOT have cam bearings. Again no problems with reliability

High revving, lower Torque than 1500

<u>The 1296cc Mk4 Engine: 6000 Rpm Standard, 9000 Rpm full race</u>

This has heavier internals than the 1300, bigger inlet valves and larger big end bearings.

Unfortunately it hasn't got cam bearings.

High Revving, lower Torque than 1500

<u>The 1296cc Mk4 Engine (from FH-25000) 6000 Rpm standard, 9000 Rpm full race</u>

As the Mk4 1300 above but with a recessed lip at the top of the bores, this allows a sort of big `o` ring in the cylinder head gasket which improves the chances of a good tight seal.

High Revving, lower Torque than 1500

<u>The 1496cc 1500 Engine: 5500 Rpm Standard, 6500/7000 Rpm full race</u>

Long stroke, no cam bearings and the block top cylinder recesses.

This is the tricky one, dreadful blow up lump or a misunderstood badmouthed high torque engine perfect for easy street driving? Triumph faced a dilemma in the face of US emissions requirements strangling their engines with not enough cash to fund a new engine. In the end they just increased the crankshaft stroke to its maximum capacity bringing the engine to 1496cc.

This means that for any given Rpm the pistons are moving faster up and down than on any of the other Spitfire engines, this equates to more stress. I spoke to the Triumph Tune Spitfire guru TERRY HURRELL, who personally owns a 120 Bhp 1500 as a daily driver.

He put it simply and clearly:

"If you want to win races with a screamer engine go for the 1300, if you want a good Torquey road car get a 1500".

His 120 Bhp 1500 has so far completed 60,000 miles in a manner probably not approved of by Triumph (in other words thrashed to within an inch of its life) while putting out nearly 70% more power than standard.

Its still going strong, I think that about wraps this old debate up. I must add that his 1500 managed that in no small part because it was rebuilt properly and tuned with the correct components. If you do the same you can have a reliable 1500, his other big tip was that "An oil cooler is a must, especially on the 1500". Also use good quality oil & change it with filter every 3000 miles. Do that and your happily away for a good 100,000 miles of fun.

The 1500 is a low revving, high Torque engine. In a fully stock motor avoid revs above 5500.
A prepared engine, balanced with stronger rod bolts can be safe to 6000 Rpm. Still, remember that its not an engine for thrashing at high Rpm. Respect its limits and it can be reliable!

Not a Spitfire Engine please!

Originally I was going to make this a Spit engine only guide but due to the number of Spitfires going around with everything from Fiat Twin Cams to 5.7 litre Chevy Small Block V8s (I believe the name `small block` to be the American sense of humour at work!) I thought a small section on transplants would be useful.

Why should I use a different engine?

If you don't care about originality and you're faced with rebuilding and modifying the stock engine at great cost you could think about a transplant. It can be tempting as you can pick up a low mileage Alloy block 4.6 Litre Rover V8 for less than a rebuilt & modified Spitfire engine. The cost factor isn't really a good motive as it might have appeared. By the time you have uprated the suspension, brakes, drivetrain & chassis to cope the total cost can be high.
Inserting an engine which as standard produces as much Bhp as a race prepared Spit engine can be the easy option. The more radical you go the more expense and more engineering flair you will require. Of course if you have too much money you can pay people who are professional engineers to do a lot of the work for you. Deduct suitably large sums from your bank account before proceeding.

How much will all this cost me?

It depends, if you put in an engine of less than 160 Bhp or so then the rear drivetrain can remain almost stock. The brakes & suspension would also require minimal modifications (that is to say straight bolt on ones). Any American V8 engine even if with less than 170 Bhp or so will be too much for the drivetrain as the Torque it produces will be considerably higher than 170 ft/Lbs.

The higher the output of your engine is the higher the conversion cost will be. If you put in a 350 Bhp V8 (this has been done) you will require to be realistic at least £5000 (not including engine cost). On top of this you will need to have good fabrication & welding skills and a friendly local machine shop. If you are really cunning it may be possible to do a swap for much less than that but in the real world that is probably a good basic estimate for a good job. And more importantly a SAFE car than won't go falling to bits or twisting in inappropriate places.

Once you start delving into putting new suspension systems in to cope with the new power you have opened a new can of worms even bigger than that of engine modifying. Suspension is without any doubt the most infuriating aspect of any car in that there are never any real golden rules which when followed result in success. Even the experts with virtually unlimited resources and fiendishly clever computer programs have still not achieved the goal of keeping all the tyres vertical to the road at all times.
You should be very cautious before attempting any such work with real hope of an acceptable conclusion. It's shockingly easy to end up with something that handles like an early Corvette or other road horror.

Which Alternative Engine should I choose?

If you start from scratch it makes sense to pick the best of the bunch. If you choose the engine there is no excuse for getting an unreliable and expensive motor.

Weight is crucial, remember that the only reason your Spit is nimble and `chuckable` is that it weighs (in comparison to many) about as much as an empty crisp packet. If you put in a Chevy / Ford / Mopar / Pontiac cast Iron V8 engine in you will loose much of that nimble nature which so endears us to the little car. Here is a rough guide to how much various engines weigh. It does not include transmission or small engine bits like alternators and starters. Also I only had access to very precise figures on the V8 & V12 engines. The rest should be accurate to within about +/- 5%.

- Standard Spit:........... 125 Kg...............71 Bhp
- Vaxhaull 16V..............130 Kg..............120 Bhp
- Ford Zetec.................135 Kg..............120 Bhp
- Triumph Sprint 16v...140 Kg..............127 Bhp................(nice to keep it Triumph)
- Rover V8:...................145 Kg..............150>190 Bhp........ (depending on capacity)
- Cosworth DFV (V8)...145 Kg..............400>500 Bhp........ (not a real option but an interesting comparison)
- Ford Cosworth 16v....150 Kg...............200 Bhp.............. (Bhp can be double that with sufficient cash)
- Triumph TR6..............200 Kg..............135>150 Bhp........ (depending on spec)
- UK Ford V6................200Kg................145 Bhp................ (might as well use a V8)
- Ford 289 V8................222Kg................190 Bhp
- Chev V8 S-Block........261Kg................250 Bhp
- Ford V8 S-Block.........265Kg................250 Bhp
- Jaguar V12.................309Kg................300 Bhp
- Chev V8 Big Block......313Kg..............400 +Bhp
- Ford 427 Big Block.....318Kg...............400 +Bhp.............(the powerplant of the mighty AC Cobra 427)

Transmission Weights: (all but the Spit ones do not include bellhousing weights)

- Standard spit with OD & Iron Bellhousing.......42Kg
- Standard spit with OD and alloy B-Housing....34Kg
- Tremec 5 speed (alloy cased US Toploader)...45Kg

- Toyota 5 Speed..35Kg

So for transmissions (gearboxes) you can generally add 40 Kg to any of the engines. Remember that the TOTAL weight of a standard Spitfire is only about 790 Kg!
If you put in a big block V8 the engine & transmission itself will be almost HALF the weight of the whole car!

Now I know that it is possible to move the engine so far back that the percentage distribution of weight is better than standard but that does not alter the fact that you have just put 350 Kg of cast iron on a tiny sports car.

Remember that you will need to obtain a COMPLETE engine & transmission unit. Locating one later can prove to be an expensive operation. Even if you could, putting a Spit gearbox on a V8 or a powerful 4 cyinder engine is just plain stupid.

American V8 Engines:

As we have seen they are very heavy. However they have several big plus points.

1: They are utterly 100% bullet proof and should go on almost for ever.
2: New engines & parts are dirt cheap
3: A truly VAST range of cheap race parts are available
4: You can very easily get more than 400 Bhp out of any small block V8 with minimal modifications
5: If you have around £800 to spare you can get Aluminium heads for any US V8. This takes weight down to 205 Kg.
6: If you have too much money you can also get Aluminium US V8 engine blocks. This along with alloy heads makes them about the same weight as the light Rover V8. Bank on at least £2500 for one bare block.
7: The Rover V8 is just a design Buick sold to the UK many moons ago, Rover V8 parts are much more expensive than US V8 parts and due to its smaller capacity will never be as powerful with the same expenditure.

As a point of note you can buy a virtually complete BRAND NEW Chevy V8 small block engine for £1300, a reconditioned one (with heads too) costs a measly £900 from REAL STEEL in the UK. Those in the US will pay even less.

If you put in an engine with more than about 160 Bhp the entire drivetrain & suspension will need to be totally reworked, a subject in itself worthy of several thick books.
Think carefully, the Spit diff will not like the sort of astronomical Torque a smaller American V8 even in standard from churns out.

Rotary Engines:

These are worth a mention as I was most impressed by a Mazda rotary into Spitfire conversion that Grass Roots Motorsport magazine covered.

Rotary engines are internal combustion engines that use petrol. That is about where any similarity ends. There are one or even several triangular rotors in a main housing, there are no camshafts, rockers, cranks, pistons, rods or other gubbins to get in the way. Hardly any moving parts equals spectacular power/capacity efficiency and very low weight.
They also rev up fast and run as smoothly as silk. Mazda now does a Turbocharged version, which with a

couple of hundred horsepower which should be interesting!

The concept is utter genuis and was pioneered by a chap called Wankel, there are only two good reasons why it didn't take over the world.

1: They use lots of petrol (25 MPG is the best you can hope for).

2: The problems of sealing the rotor tips to the block walls have only very recently been fixed by Mazda after everyone else gave up.Almost everyone from GM to Rolls Royce tried to fix the rotor tip seals without sucess. Many owners of the original RX7 angrily tore out the Mazda engines when the rotor seals blew and put in Ford V4s. Oh dear.....

These days the seal problems are fixed, I don't know how the fuel economy is doing but it's a very fine engine now that the teething problems are over.

Working Cleanliness

To enable an engine to be reconditioned (and last well) good general practice must be taken, cleanliness is the overriding maxim. The block and head should be chemically dip cleaned twice, the core plugs and oil gallery plugs should be removed prior to this.

Cleaning should be done once before machine work and once after to clear out any metallic production swarf. The cleaning of the block before machine work might seem odd but it is difficult to align an engine block squarely on a milling table if its covered in 20 years of grit clogged oil. If the company in question doesn't mind putting horribly oily and mucky engines in their machines you should also be asking yourself how much care they are putting into the rebuild.

Compressed air is often used to blow through oil ways to ensure clear passage for the lubricant, I would not attempt it without an in line air filter and a dedicated blow gun which is kept spotless. The chemical dip will be sufficient provided all engine core plugs etc. are removed before hand.

All components (even brand new out the box) must be cleaned in paraffin, never soapy water as most soaps contains salt (and it doesn't work as well as paraffin!). The crankshaft oil ways must be carefully cleaned with small brushes and paraffin (ones meant for cleaning test tubes are perfect).

Grit or dirt acts like an abrasive paste when in oil, slowly grinding up the internals of your engine. Oil can cope with minute metallic particles by keeping them in suspension. Bigger garbage will be fatal to your new engine.

When inserting the bearings you must maintain an absolutely spotless working environment, even one tiny bit of grit or metal will badly score a crankshaft journal and grit behind a thin bearing shell will make it assume an oval shape once assembled which will kill your bearings very efficiently.

Magnaflux or Similar:

Magnaflux is one technique used for crack detection in engine parts, it is 100% essential to have this operation on your crankshaft, con-rods and block.

I polished up the con-rods on my spit engine, when I got to a smooth finish I noticed small hairline fractures

on one rod.
I had not had them crack tested.

Had I not spotted it the con-rod would almost certainly have wrecked £1000 worth of new engine. The crack test would perhaps have cost less than one tenth of that. Even then I only spotted the crack when I polished the metal. The moral of the story is: GET THE ENGINE CRACK TESTED!

If you find ANY cracks no matter how small in any engine components put them straight into the scrap bin. I heard of a bloke with a Spitfire who had the engine block welded up after a crack appeared, I don't need to tell you what happened after he started it up again do I...

Finding a good machine shop

The first Spit engine I had done was delivered to me in an appalling state from the machine shop. It was very badly wrapped and dirt and grit had got into the packaging, the block had not been dipped and they had not even replaced the timing chain tensioner. This was from a machine shop on an airfield that did aero engines! It goes to show always to be very suspicious.

The classic warning signs are things like dirty oily workshops, old engines lying around outside rusting and unknown companies who don't have a reputation to keep up. A really good engine rebuild outfit will have clean workshops, clean looking well maintained machinery and will probably give the impression of taking an almost surgical approach to their work.

They should ship out their engines shrink wrapped to keep them clean, ask them what their processes are for rebuilding an engine. If they don't show you a chemical dip tank or similar then walk away, accept no excuses;

No chemical dip = A dirty unreliable engine

Some chemical dips like Caustic solutions actually dissolve Aluminium. For alloy components they are usually steam cleaned with a very powerful jet pump washer. Anything up to several hours are required with a block to ensure its nice and clean throughout. If you put an Aluminium block in a Caustic dip overnight you will find it quite empty in the morning!

Crack testing should be a mandatory procedure there too.

The best outfits will charge you perhaps 50% more than the `bloke round the corner you met in the pub last week`. By the time you have either had it done properly or worn the engine out in 20,000 miles the total cost is very similar. The inconvenience and stress from having to get it done again properly is considerable.

I recommend you go to a reputable machine shop who have experience with your engine,
(or at least 4 cylinder engine work). A well known company will not give you a duff engine when they have spent 20 years building a reputation for excellence. Motorsport oriented companies in particular depend upon their reputation for business.

CES Power in the UK build race winning engines, they have been used by some of the most illustrious teams in racing yet they will happily machine you the man on the street an engine for much less than you might imagine. Putting it all together once the machine work is done will save you about 20% on the cost of an in house build. Certainly CES Power can make a Spit engine better than new for less than the cost of two cheap and sloppy rebuilds.

With engine rebuilding you really do, without exception get what you pay for.

The same goes for cylinder head gas flow work, Blysenstein engineering in the UK do heads for many top race teams but will do a gas flow on a spit head for around £300 ($420 USD). Buying quality saves in the long term, where head flow work is concerned this will guarantee no horrid disappointments when you fire up the "new" engine to discover it is not any more powerful than before. Or if you are very unlucky even worse than before.

Of course the above names are just examples of what you should be looking for.

Required Tools For a DIY Engine Build up:

Building up the engine yourself will save money and give you peace of mind that it has been done with care. Having said that if you don't feel up to it or don't have a very clean workspace in which to assemble it perhaps get it done for you.

You will need the following tools:

- Vernier calipers (good stainless steel ones accurate to 1 thou.).......................... £20>30
- Dial gauge with magnetic stand... £20
- Good quality torque wrench/s with capacity up to 150 ft/LB.............................. £40
- Micrometers 0-1", 0-2" and 0-3" (not strictly 100% essential but very handy). £65 (for 3)
- Telescopic Gauge Set (for internal measurements) £20
- Piston ring compressor £8
- Valve spring compressor £10
- Circlip plier set £10
- A 1-13/16" socket for the crank pulley nut £18
- A set of feeler gauges £5
- Preferably an engine stand (surprisingly cheap) £45
- Paraffin (lots of) and various brushes etc. £15
- Hex keys (various) for oil gallery plugs etc.....................£10

Micrometers are not absolutely mandatory and are not as versatile as a Vernier Caliper. However they are very accurate indeed which is handy. You will need some form of external measurement gauge to use the Telescopic gauges, themselves they have no markings but spring open and lock in a bore. You them take it out and measure it with Vernier Calipers or Micrometers.

Cheap Micrometers use one measuring spindle and several different bodies instead of one for each stage as they come in one inch steps. These Micrometers are however a pain in the neck as you need to fiddle and take it to bits every time you want to measure something different. Cheap and probably totally sufficient ones cost about £20 each, top of the range ones made by Moore & Wright in Sheffield cost £65 each and upwards. In exchange for this they are accurate to 0.0001 inches.

Internal Micrometers cost £100 and upwards each. This is why you use Telescopic gauges.

I recommend you try to pick some up second hand, Moore & Wright ones will last for ever and you should never be worried about their accuracy no matter how old they are. Closing down machine shops etc often have big clearouts of almost priceless gear for absolute peanuts.

Dynamic Balancing £90

What is it? Well dynamic balancing is so called because the rotating components (pulley, crank, flywheel & clutch cover) are balanced by spinning them up to speed on a special machine.

They will also attach lead shot filled weights to the journals where the con rods are usually placed to simulate their effect. The machine indicates where to add or remove material from the crank counterweights to achieve balance. As standard Triumph engines were not very finely balanced, you will notice a big difference after a pro balancing job. Good balance improves bearing life and makes the engine run more smoothly.

You should also ask for the con rods to be balanced between each other and end to end if you can afford the extra. The pistons should also be matched in weight to the lightest one. Within 1 gram is the level of accuracy you require.

The clutch cover is balanced in its place of manufacture but there is no guarantee that the locating dowels for it on your flywheel are perfect!

What is `Blueprinting`? £ lots!

This is an often abused term, if you get the engine rebuilt it is NOT blueprinted.
Proper blueprinting will be an additional expensive and one not needed unless you are in possession of a good budget and making a race engine. In essence it is thus: Look in your Haynes (or similar) manual and for almost every engine dimension it has a tolerance.
Example: The crankshaft end float on a 1500 is quoted as 0.006">0.014". Most engine builds will just ensure that it is within those figures. That is fine for a street engine. For a big budget race engine the machine shop will supply the crank end float at exactly 0.010". Not one thousandth of an inch more, or less.

Imagine a similar exercise in precision applied to each and every single part of the engine, the line of the crankshaft will even be checked to be exactly parallel to the deck top. The bores will be machined exactly 90 degrees to the crank and not just centralised on the old bore holes.

Done properly this is very expensive and not needed for a street engine.

The next time your mate claims to have a blueprinted engine you can confidently look them in the eye and say 'No you don't!'. The exception to this is if your friend is rich....

A good modern machine shop will (if asked to do so) machine your spit engine to closer tolerances than original factory ones and this will be beneficial. It is not blueprinting, in blueprinting there are no tolerances. It is exactly one thing or it is not. This is the level of accuracy required to beat everyone else on the track, this is not the required procedure for a powerful but reliable street engine (OK it wouldn't hurt but its a bit silly unless you are rolling around in cash).

How much power can I realistically get?

A Spitfire engine suitable for easy road use can be modified to produce a maximum of about 55>60% more power than standard. This does not include such things as Nitrous Oxide or any form of forced induction (like supercharging). I regard these options (for the Spitfire engine at least) as alternative means of reaching the same power output as a conventionally tuned engine. If you put a turbo on a 1300 already producing 120

Bhp it would probably either blow it up or reduce its life to under 10,000 miles.

As you may have noted and were just thinking "hang on you said Terry Hurrells car has 69% more power" remember that his car also has roller rockers and a cam that does require a little more cunning than many would like to drive in traffic. Its up to you and your limits. Nearly seventy per cent more power can be yours but the expense goes up about £500 over the 60% more level and the driveability does suffer a little.

A three bearing crankshaft (and a long throw in the 1500s case) eliminate the possibility of higher outputs with the sort of reliability needed for street use.

To my current knowledge the highest power a 1300 racer has achieved with moderate reliability (and short life) is roughly 145 Bhp at the flywheel, about the same is true of a 1500 as the 1300 in race trim can reach 9000 Rpm when prepared correctly. I don't know of anyone running a 1500 even with a steel crank going beyond about 7000 Rpm or so. The MGB was originally made with a three bearing crank before they modified their castings to have the almost universal five main bearings. Moss Europe refuse to build fast road MGB engines with three bearing blocks.

It simply cannot provide sufficient crankshaft rigidity to guarantee reasonable bearing life. The long throw of the 1500 crank exasperates the problem as the pistons move faster imparting higher stress upon all the main engine components. As you probably know this is one big reason why the racing boys mostly use the 1300 engine, for street use though the 1500 even when modified can be reliable.

The safe mechanical ceiling is well known has been reached, exceed it at your peril (well your Spitfires peril anyway!).

This means that at the flywheel you can realistically expect the following from a well built and carefully assembled engine.

1300 & 1500 engines: (the TORQUE will be lower for the 1300 but Bhp will be very similar due to a higher Rpm limit on the 1300s). This should not confuse you if you have been an attentive reader and read the later section on what horsepower really means....

- Balanced internals, 9.75/1 compression, bigger inlet valves, fully gas flowed cylinder head, fast road camshaft, duplex timing chain & vernier adjuster, electronic ignition, water & cooling etc sorted, twin SU carbs with good air filters & decent 4-2-1 tubular exhaust manifold (with the rest of the system too). 105>110 Bhp.

- As above but with Twin Weber 40DCOE sidedraught carburettors: 115>120 Bhp.

- Full race 1300, twin Weber 40DCOEs / Fuel Injection, full engine mods, radical race only cam etc. 130>145 Bhp

These limits are well known so if your mate thinks he has a killer road going 1300 with 160 horsepower just nod and pretend you're impressed....

Unfortunately it's just not going to happen I'm afraid. (well not for more than 5 minutes with Nitrous or a Turbocharger until it breaks in spectacular fashion).

What is a dynamometer? (£80 an hour)

A dyno is basically a big test bed for an engine, the engine is strapped in and run up. This can measure a precise Bhp/Torque curve which is how all the best engine components should be made. They see exactly what effect various components have upon power output.

What is a Rolling Road? (£70 an Hour)

A rolling road is a machine for measuring horsepower, torque and for tuning the engine under load conditions when the most useful observations can be made. (its difficult to tune the carbs by leaning out the window at 60 Mph).

The wheels sit on rollers which are turned by the engine. A torque / Bhp curve can be printed off for your engine. Initially the power is `at the wheels` power. This is flywheel power minus transmission, axle and tyre losses. Generally you can deduct 15>20% from flywheel Bhp to get at the wheels power.

This is the ONLY real means for tuning Weber DCOE carbs and Fuel injection.
SU set ups can be optimised too. Bank for two hours maximum.

They really push the engine here so fill up with petrol and check oil/water carefully.
You cannot have this done until the engine is properly run in.

What is Bhp and Torque?

There is much confusion about this and it took me some time to figure out. Bhp is calculated FROM the torque and rpm level. Torque is the actual turning force the crankshaft produces, if you think of putting an imaginary 1 foot long bar at right angles on the end of the crankshaft with some scales on the other end of the bar. Now imagine you had to place 100 pounds of weights on the scales to stop the crankshaft turning. The torque the engine produced would have been 100 LB/ft.

If 300 pounds of weight was required then the engine produced 300 LB/ft of torque and so on.

For practical reasons a dynamometer does not operate quite like that! The theory is identical however.

If you have an engine built by a pro outfit they can actually run in the engine on their dyno so you can drive off as fast as you like with a brand new engine knowing it to be run in and tested.

Bhp is (very basically speaking) the torque an engine produces multiplied by the Rpm.
This is why when looking at a Bhp/Torque curve the Bhp can rise even after the torque has tailed off.

Example: If at 7000 rpm torque is down 5% on 6000 Rpm, the Rpm is 16% higher so Bhp still rises by 11%.
Eventually the loss of torque outweighs the rise in Rpm and the Bhp levels fall.

For the mathematically inclined the proper calculation is thus (there are several different methods but all result in the same answer).

If Torque @ 4000 Rpm= 245 LB/ft (a very unlikely scenario for your Spitfire!)

Bhp=245x4000 divided by 5252.

=186.6 Bhp @ 4000 Rpm.

The figure 5252 is derived from calculations made by a clever Scots engineer James Watt to measure the amount of work achieved pulling horse drawn loads. Therefore ALL Bhp/Torque charts MUST without exception cross at (or in practise damn near) 5252 Rpm. If this does not occur someone is telling you lies!

When choosing components (like camshafts) it is very easy to be seduced by the Bhp.
A full race cam @ 130 Bhp or a sensible one @ 110 Bhp. Where is the contest?
Well the higher power is produced by higher operating Rpm and the sacrificing of the torque at all low Rpm levels (like all the ones you need for street driving). The torque is very important for the road car and should never be ignored in a silly the quest for `ultimate Bhp`.

Actually Getting Started: *The Cylinder Head*

Now that some basic information has been learnt the practical aspect can begin.
Often tuning companies refer to things like `Stage 3` engines, there is no standard definition for such things and you should check carefully exactly what is included. Roughly speaking it goes as follows for cylinder heads:

Stage 1:

- A 4-2-1 tubular manifold with straight through silencers
- K&N High flow air filters (or similar such as Ramair or Pipercross).
- Richer carb needles to supply more fuel as potential flow rates are now increased

Stage 2: (keeping 4-2-1 system and K&Ns)

- Richer still carb needles
- Cylinder head flow work, clean up of ports and un-shrouding chambers

Stage 3: (still with 4-2-1 system)

- Richer SU carb needles or Twin Weber DCOEs
- Fast road camshaft (such as Triumph Tune 'Fast Road 83')
- Fully flowed head inc. 3 angle valve seats, recessed bronze valve guides, waisted stem valves, slightly stiffer valve springs (to cope with higher rpm), bigger 1.475" diameter inlet valves. Compression > 9.75/1 (sensible maximum with street fuel to avoid pre detonation)

Stage 4: (4-2-1 system) or 4-1 system for max. top end power (about 3 extra Bhp)

- Twin Weber 40DCOE carbs (or injection)
- Race or Radical road camshaft
- All above head mods with bigger 1.25" exhaust valves
- Roller rockers (more valve lift as the ratio is different and less friction)

- Chrome moly tubular push rods
- Lightened cam followers

This is only a guide and many components can be safely mixed between stages if desired, you CAN put roller rockers and chrome moly push rods on an otherwise standard engine. I would think it to be both expensive and a bit pointless to do but...

Parts Price Guide:

- Chemical dip £10>30
- Set of bronze valve guides £30
- Valve guide oil seals £15
- Set of 8 stainless steel waisted stem big valves £90
- Gas flow labour charge £200>300
- Roller rockers £300>400
- Chrome moly push rods £50
- Lightened cam followers £30
- Fast road camshaft £70>90
- Stiffer valve springs £25
- Alloy valve caps £25

General Cylinder Head points to save money & sanity:

- Bigger exhaust valves are pointless for all but a race engine
- Roller rockers are very expensive and are not ever a must have item unless trying to win races.
- Chrome moly push rods are only there to save a little valve train weight to allow very high rpm and quicker spin up; the same goes for alloy valve caps.
- Only the exhaust valve seat needs to be replaced to use unleaded fuel.
- Grinding the ports out as big as you can get them will NOT give you lots of power.
- 9.75/1 is a good practical compression ratio limit for a street engine running 92 octane fuel.
- Skimming to increase compression will alter rocker geometry. This will need shorter push rods or very thin spacers under the rocker pedestals. Don't forget that there is the rocker oil feed through the end pedestal though!!
- Stiffer `uprated` valve springs are ONLY needed for higher Rpm. If you stick to less than 5500 Rpm you don't need them
- Slightly Shorter valve guides are fine to an extent to get some of them out the port but go too far and the limited valve>valve stem contact area gives rapid wear and possibly over heated exhaust valves as the heat has a harder time dispersing.
- Use valve stem oil seals, just about every engine on the planet except Spitfire engines use them. They slip over the top of the valve guides. These are Ford Pinto items (UK Ford), available from Canley Classics in the UK. They cost about £12 a set.

You may need to loctite them in place to the top of the valve guide.

>

Advanced Head Modifications:

- Waisted stem valves:

These are just valves with the stem narrowed slightly near the valve tip where it passes through the port. This just limits it infringement into the port and makes the valve stem less of an obstacle for the gas. These are available from Triumph Tune (of Moss Europe).

- **AR exhaust manifolds**. Stands for ANTI REVERSION. I know of no company offering such a manifold for the Spitfire so if you want one its going to be a one off custom job.
Firstly this is of very little practical use in a standard engine, it only becomes useful when more and more radical camshafts are used with more progressively highly tuned engines. Maximum benefit will only result in a full race engine.

When a really radical camshaft is used often the `valve overlap` is considerable. This means that there is quite a bit of time when both inlet & exhaust valves are open in the SAME head chamber. This is basically to keep the valves open as long as possible to allow the maximum time for fuel to go in and waste gas out.

The problem with this is that its very wasteful of fuel as some goes straight out the exhaust (ever wondered why many race car exhausts flame?), also some used gas gets sucked back into the chamber. This obviously reduces power, race cars are generally not interested in good fuel economy so the AR exhaust manifold just tries to limit waste gas suck back into the chamber. Only a problem with big overlap race cams.

To do this it has a 1>2" long bit of tube INSIDE the beginning of the exhaust manifold tube. The outer tube is flared to allow no reduction in bore diameter. This is a sort of `Gas Flow Barb` like on a fishing hook, gas flows out easily but if it tries to go back then the sharp tube end inside the outer tube creates turbulence. This makes it more difficult to reverse gas flow back into the chamber and makes a small but useful increase in race car power.

- Triple or even 5 angle valve seats:

This just makes a less difficult path for the gas to flow.
That equals less turbulence which = more flow which = which = more power.
These days its not really a big deal and most head shops will do it at very modest extra charge. Some even do it as a standard procedure. Five angles is only slightly better than three and should ONLY be used on race cars, this is because it limits too much the valve seat area. This means that it wont give sufficient longevity for a road car.

- Twin Spark plugs per cylinder:

More common in the motorcycle & aero piston engine world. The idea is to burn the fuel/air mixture more fully.
This as far as I know is of most benefit in Hemispherical shape combustion chambers, not the sort the Spit has.

Having said that the Alfa Romeo company made a quite superb 4 cylinder car engine with twin plugs called (rather unimaginatively) an Alfa Romeo T-Spark.

The modification might be interesting to mention though, it can be performed by THE CYLINDER HEAD SHOP in the UK. They have some very advanced machinery there and practically nothing is `no can do` with them.

This chamber shape is however that used by both the Dolomite Sprint and Rover/Buick V8. Perhaps owners of Spits with these conversions might be interested. The machining work will cost about £150 per head and a special ignition system will cost anywhere between £350 and £1000. Such as custom twin spark system is available so if you're the try anything for power mentality no matter how lunatic then perhaps its worth some investigation. The maximum power gain you are likely to get is about 5%.

Cylinder Head FAQs:

Why doesn't grinding out the ports to make them really big give more power?
Answer: The amount of mixture reaching the chamber is dependant ultimately upon the valve size, calculations have shown the optimum port diameter to be exactly 0.8 that of the valve. If the port is smaller than this then enlarge it to be the correct diameter. Any more and no more power will be produced.

Also if you make it too large the velocity of the gas slows too much and fuel drops out of suspension in the air, at this point low end power will be reduced considerably. Only at very high Rpm could sufficient flow velocity be maintained. Optimum gas velocity for a race engine is about 230 Feet per second, for a road engine it is about 170 and upwards.

What is manifold matching and do I need it?
Answer: Quite simply the inlet and exhaust manifolds are crucial for the induction and removal of fuel and waste gasses. Now as standard the openings in them to match the head ports to manifold ports are pretty vague and a measurable improvement can be had by a good manifold matching job. Both exhaust and inlet manifold can be beneficially modified in this manner.
To do it the shop may insert dowel pins into the head and drill location holes for them in the manifold flanges. This ensures correct line up which can be a hit and miss affair with the standard studs & nuts approach.

Then the manifold gasket is placed over the front of the manifold flanges, a fine scriber is used to mark its outline on any intruding material. The gasket is removed and a die grinder used to carefully open the manifolds ports to the gaskets dimensions. When the cylinder head is gas flowed they should as a matter of course perform this operation on the head itself.

Why are exhaust valves smaller than inlet valves?
Answer: The bigger one valve is the smaller the other has to be, the pressure expelling the exhaust gas is considerably higher than the force sucking in air through the inlet tract.

Why are overhead camshafts better than OHV heads?
Answer: They throw away several moving parts reducing frictional losses and allow much more accurate valve timing as the camshaft acts almost directly upon the valve.

Why are 4-2-1 headers better for a road engine than 4-1s?
Answer 4-1s supply more peak Bhp but at the cost of mid range power, which is what you need for a practical road engine. Also 4-1 headers are also almost impossible to fit to a right hand drive Spitfire because of the steering column.

What is optimum exhaust back pressure?
Answer = None! The reason most engines (except top fuel dragsters and the like) produce more power WITH an exhaust system is than believe it or not air has momentum.

The air rushing down the exhaust manifold actually sort of `sucks` the last of the spent fuel out of the cylinder, big supercharged or turbo engines running high boost don't apply as the pressures are so high that the suction factor doesn't really have any more effect. You can make an exhaust manifold with too big pipes for much the same reason why you can have too big inlet ports.

The gas speed drops and any momentum is reduced, (minus the point about fuel suspension).

What about the external rocker oil feed kit?
The only really concrete thing I can say is that every Spit engine I have stripped down had totally knackered rocker shafts. This makes valve clearances impossible to adjust accurately and is not good for oil pressure. Possibly connected is bad wear to the end camshaft journal as it supplies the rocker shaft, as the oil gaps increase more oil would be taken from the cam.

Some say rocker feed should be sacrificed to maintain the more important main bearings, some say synthetic oils can make the standard feed fine. I don't know for sure but I will be using the external feed with grub screws blocking off the original feed. It was a weak point in the head gasket too and often leaks oil out from the rocker feed.

I have also heard from owners of 6 cylinder engines that the oil pressure drop when fitting the feed was too much. My personal opinion on this is that this may well be so on the 6 cylinder engines. Why? you ask me. Well the bigger 6 cylinder engine has the SAME oil pump as the smaller 1496cc Spitfire engine. That means its pretty much stretched to capacity, adding the oil feed may be just a little too much for it. The smaller 4 cylinder 1496cc engine has extra capacity to spare over the bigger 2 litre engine to I personally wouldn't worry about that aspect.

You will really just have to make your own mind up.

Actually Getting Started: *The induction system*

The standard SU carbs are fine providing they are in good condition, and are suitable for all but a highly tuned or race engine.

A range of needles are available and correct choice is essential if the potential of your engine is to be reached, the choice is different for each engine depending on its state of tune and capacity. A knowledgeable supplier or rolling road will know which to try. They are not expensive at about £10 a pair.

Performance Mods for SU Carbs: Tools, Parts & Operations:

One hour on a rolling road £100
Every additional hour beyond that £50
Gas flow carb balancer £15
Colourtune £20
Set of two needles £10
K&N Air filters £45
Plain choke plates £15
Plain jet conversion £30
-A 1500 as standard will need 1.5 SU`s and the 1300 engine when tuned will benefit from these too.
- K&N air filters are really good and will flow more air and provide very effective filtration. Most Formula 1 teams use K&N air filters. Legendary engine builder Dave Vizard refused to use anything else after extensive engine dyno. testing.
- Get rid of the silly waxstat jets and buy a plain jet conversion which includes everything you need.
- Get rid of the round choke plates with the valves in, fit plain ones.

- Make sure the carbs are in good condition, worn spindles let in air which makes for a lean mixture. Get them tuned professionally or do it yourself if you have some basic tools.
A colourtune and a balancing gauge will be helpful and more accurate than the traditional methods of home tuning.
-You can flow SU`s by grinding the internals in set places to improve flow. This may increase potential top end power by perhaps 4%. Books are available to which show the correct procedures but personally I wouldn't like to advocate messing with the carbs to that extent.

Modified as above (minus any grinding etc.), twin 1.5 SU`s will provide a 1500 with up to about 110 Bhp.

Although rolling road tuning is only a must have for Weber carbs SU`s will benefit too and to achieve maximum potential you should consider it.

Here is a very rough guide to choosing needles for your SU carbs: 1.25s on a 1300 and 1.5s on a 1500:

The three letter code is stamped on the big end of the needle:

Standard 1300cc AAU/AAN
Stage One 1300cc AAQ
Stage Two 1300cc AAM
Stage Three 1300cc ABY

Standard 1500cc ABT/ADN
Stage One 1500cc AAQ/AAT
Stage Two 1500cc AAM/AAB
Stage Three 1500cc ADQ/AAL

Weber DCOE Sidedraught Carbs:

Prices:

A brand new Weber 40DCOE jetted correctly....... £217 each
Set of manifolds for twin Webers........................... £80 a pair
Twin cable linkage £40
Induction ram pipes..£22 a pair
Pair of K&N Pancake Air Filters..............................£65 a pair

Old Myths and Tales:

-Weber DCOEs go out of tune after a while.......No they don't!
-They use loads of petrol ....Only because you drive the car harder now it is more powerful and much more fun.

Truths:

-Weber DCOEs are not really suitable for home tuning
-Properly set up and tuned there is little difference in power between DCOEs and fuel injection
-Webers are very well built and will be 100% reliable
-Webers do need to be set up on a rolling road

Weber DCOE carbs have an almost legendary reputation in European racing circles, in the days before injection it was a common sight to see an impressive bank of Weber carbs strapped to the latest racing machine. Weber have put in a large amount of research into the design of their carburettors and make probably the best carbs you will find anywhere in the world.

This might sound a bit stupid but they are called `sidedraughts` for a good reason, they must be mounted horizontal. This is because of the float chambers. If you want a different arrangement get different carbs. Weber also do downdraughts comparible to DCOEs.

Most if not all horror stories about these carbs I am convinced come from people either putting them on set up wrongly or putting them on an engine not set up to benefit from them, I read a magazine story about a chap with a standard 1800cc MGB. He thought that twin Webers would make the car fly, he fitted them and low and behold it just used lots of petrol and wasn't really any more powerful at all. If your engine is not modified to take advantage of superior carburation it is a pointless and expensive exercise so think carefully. If you don't have a fast road cam, flowed head etc. you don't need Weber DCOEs.

Probably the best analogy I've heard for Weber carburettors is to imagine them as very expensive running shoes. If your engine is old or just bog standard its just like giving 90 year old Granny some Nike Air trainers and expecting her to leap around all over the place. If the basic building block is not up to it no amount of fancy extras will make a bit of difference.

With engine building you must start from the ground up and have a solid foundation upon which to build, to do otherwise is not going to get you anywhere fast except perhaps the breakers yard looking for a new engine!

If you have any reservations about Weber DCOEs remember that such classic marques as:
Alfa Romeo, Aston Martin, BMW, Chrysler UK, Ferrari, Ford, Lancia, Lotus, Maserati, and even the absurd (but undeniably awesome) Lamborghini Countach with nearly 500 Bhp straight out of the factory all had Weber carburettors specified as standard equipment by the manufacturer. Not just any either Webers either but DCOE Sidedraughts.

They are considerably better engineered than SU`s and are far more flexible and versatile, as well as being able to flow more than enough air for any Spitfire engine.
DCOEs are made in several sizes which relate to the bore of their induction barrels.
38, 40, 45, 48 and even 50. These are the overall barrel sizes in mm, alternative chokes and auxiliary venturis are available to alter the effective barrel diameter even on the same carb.

If you want to fit a single DCOE then the size you will need is a 45, for twin carbs you need 40s. This is very important and you wont be able to get satisfactory operation if you choose the wrong size.

Also if buying second hand look at the number on the top plate like for example "40DCOE-31" .

The 31 (or other number) denotes which car it was originally made for, mechanically all `40`s will be the same but will have different venturis, chokes and jets for its particular application. These can all be simply replaced with the correct sizes but that costs money.

A Weber repair manual should have a table of the jets/chokes and venturis originally fitted to various carbs originally fitted to factory engines. My Webers say 40DCOE-31, the 31 denotes that they were originally belting around on a Lotus twin cam engine as well as what parts it was (should) be fitted with. Venturis and chokes slip straight out by hand so if inspecting some second hand ones it is a simple matter to check them out, the sizes are stamped upon them. Also take the top cover off to check for corrosion. If any is present in the alloy body leave it well alone. Corrosion only sometimes occurs when they have been left empty of petrol for a considerable time.

If buying new supply the dealer with the list of required jets, venturis and chokes. The carb will be supplied ready to go. Although it still needs a rolling road session.

Each DCOE has two barrels so you have one choke per cylinder, this gives fantastic throttle response and the reaction of a tuned Spitfire to the main jets opening up is enough to make even the most chronically depressed driver suddenly grin from ear to ear.

As far as I know really the only point in fitting a single 45 is to save a bit of money and make it slightly easier to set up. Either way you still need one to two hours on a rolling road to get them really on song.

Here is a list of suggested settings for twin DCOE carbs on a Spitfire, these are initial settings and may be fine tuned by the rolling road. They are much the same for 1300 & 1500s.

.........................Twin 40s ....Single 45
Choke tube:... ....30 ....33 ....£10 each (2 per carb)
Aux. Venturi: ....4.5 ....4.5 ......£15 each (2 per carb)
Main Jets: ....115 ....190 ......£3 ...."
Emulsion Tube: .....F16 ....F9 ....£3 ...."
Air Jet: ....155 ....175 ......£3 ...."
Pump Jet: ....35 ....40 ....£3 ...."
Idler Jet: ....45F8 ....45F9 ...£3 ...."

Note that the Aux. Venturis and Chokes are by far the most expensive items.
If you can get those right the jets are less expensive.

Fuel Injection:

Fuel injection works as it sounds, fuel is injected rather than sucked out the jets. This provides superior fuel atomisation and the ability to cunningly attach it to all sorts of expensive computer gizmos to give more power and economy. They tie the fuel directly to the air flow, ignition and engine temperature too. Injection also has fewer moving parts which means that despite its complexity its very reliable.

This is the ultimate in efficiency but is probably just a big waste of money and time for most Spit owners who just want a simple and fun car to fling around. Nevertheless I think its sufficiently interesting to write about.

There are no excuses to be made here, fuel injection is the best (theoretically). It can provide the most power, lowest emissions and best fuel efficiency. It can also break the bank and be only very slightly better than a well set up twin Weber installation.

I have certainly heard of and read about injected Spitfires (with Triumph engines), usual procedure is to modify the 6 cylinder Triumph TR mechanical fuel injection set up. This is perfectly possible and when correctly set up should be very slightly more powerful than twin Weber set up and have lower emissions. Bear in mind that modifying injection systems even the more simple mechanical type is likely to be very tricky work. There are allegedly problems with the seals on the Lucas injection pump with unleaded fuel too, unleaded versions are available new for about £200.

It can be an attractive proposition as you may be able to pick up second hand injection kit cheaply at a show, also the manifolds bolt right in. A luxury you won't have if you try bolt on an injection system from a local Toyota breakers yard.

Modern fuel injection is electronic and has as mini computer built around the engine it is fitted to with a three dimensional fuel/air/rpm chart tailored exactly to the engine it was fitted to at the factory. For this reason it will be very hard to use a system from a different car, changing the fuel map is possible occasionally but ask me if you can change it to suit a Spit engine and I honestly don't know.

The electronic systems do have about a +/- 10% margin of error correction built in so a common mod is to replace the air filter with a K&N air filter. This lets more air past the air meter and the electronics supply more fuel to cope. I think its a bit of a risk to assume your Spit engine will be within that 10% band of error, even the fuel map itself will still be incorrect and cancel out the `edge` that injection gives you in the first place.

Even that assumes you can fabricate your own bespoke inlet manifold.

For the rich there is a solution (like £1500>£2500), injection systems are available that bolt straight on to any engine with the immortal Weber DCOE manifolds. They have fuel maps that can be changed to suit a 1 litre shopping car to a 500 Bhp 5.7 litre small block Chevy (though the Chevy will obviously require twice as many injection runners).

Some can even be plugged into a laptop PC so a knowledgeable pasenger can try the effects of different fuel air maps while you are driving it! Wow, sadly I have not the cash for such a system, I certainly wouldn't bother with my 1500 engine either.

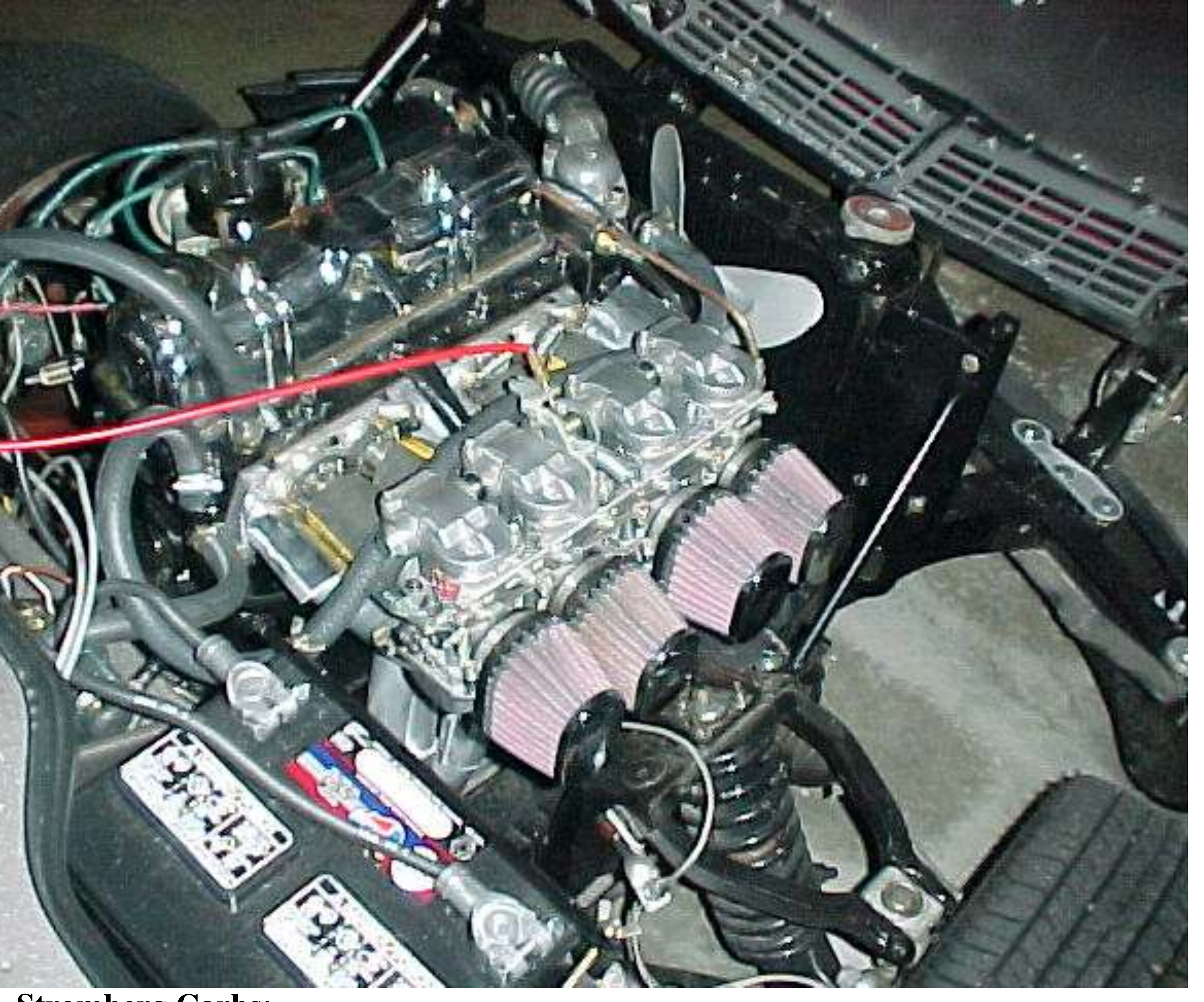
It is an interesting thought though!

Motorcycle Carb Conversions:

The Japs have again beaten us by making marvellous Carbs for those engineering masterpieces that are modern Jap bike engines. I know of one US company that does these conversions, as for price or performance I couldn't guess except that it will be expensive.

A wonderful posing asset no doubt but Weber carbs are also quite superb, more widely available, better understood at present and cheaper. A Weber set up will still give you more power than your Spit engine can ask for.

Up to you again but I reckon a bit of common sense reveals that there isn't really a lot of point unless you happen to have picked up 4 Mikunis for peanuts at a local parts sale.



Stromberg Carbs:

I have no experience of these but they seem to be roughly comparable to SU`s. I do not recommend them for a performance engine as I DO know that a much less wide selection of tuning parts is available for them than either SU or Webers.

Other Weber made carbs:

Obviously Weber make a great many different carbs and all are when set up right very very good.

The DGV is one conversion that seems common, I'm sure its superb too.
Remember though that for out and out raw power only injection can beat a set of twin DCOEs.

DCOEs are designed as the perfect performance carb and will always remain so. With most if not all modern vehicles using injection the chances of anyone else bothering with the huge investment to make a better carb than a Weber DCOE is not very big.
For a compromise on price and set up ease a DGV could be an option to consider, I have no detail available to me about how to set them up or what Bhp levels they can support so unless you know better your in the

dark on this one.

Weber also make those big quad barrel downdraught carbs, these are really for use on big `V` type engines. These are highly recommended by UK Rover V8 specialists RPI ENGINEERING, who maintain that they are superior to the usual US Holley type carburettors.

The big Weber is of course more expensive and Holley carbs have been used without problem for decades on American V8 muscule cars, there is always room for improvement however!

Supercharging, Turbochargers and Nitrous Oxide:

As I said before the mechanical ceiling has long ago been reached for Spit engines and trying any of this trickery on an already highly tuned engine is likely to be quite a dodgy exercise. If you like the thought of your con rods entering low earth orbit or want an alternative way to achieve more power with an otherwise standard engine then read on.

Note that a carb`d engine with forced induction requires no great sophistication from the carbs and many have very successfully cars have used SU carbs.

Superchargers and Turbos both do exactly the same thing, they force air/fuel mixture into the engine at above atmospheric pressure. Just how much above is up to the type of apparatus and the installation. A supercharger is mechanically driven, usually by a belt from the crankshaft. This gives it superb response times as it reacts instantly to engine speed changes, it also means it uses up a little power driving its impellers round. The instant response times are very popular with drag racers who don't want Turbo lag.

Turbos work by using the exhaust gas to turn a mini turbine, the other end of which is a small air pump for shoving fuel into the engine, they are more power efficient than Superchargers as they harness otherwise wasted energy, they also make the exhaust note quieter!

Turbo lag as the turbine runs up to speed was a big problem for early turbo cars, it had the effect that drag racers didn't like it as they didn't get the instant response and road car drivers didn't like it as the car could suddenly violently surge forward when the revs rose above 3000 Rpm and the turbo kicked in. These days turbos are much more passive and with lightweight (some times even ceramic) turbine impellers (known as hybrid turbos) have overcome most of the early niggles.

Both systems can potentially be designed to increase the power as much as you like before the engine blows up, it can seem very attractive to fit a supercharger to a standard 1300 Spit and achieve the same power output as someone who has a semi race engine with an impractical wild cam and loads of immensely expensive extras.

As before with injection the problem is finding some price practical kit that you can adapt to fit. It can and has been done, in the days of yore supercharger kits were available for various cars such as MG Midgets, Frogeye Sprites and the MGA.

The turbo avenue is tricky as it requires some fancy piping to route the gas to the turbo, it also really needs an electronic management system to ensure proper operation.

How much boost can I fit?

The limiting factors are mechanical failure and fuel pre-detonation. There is no point in fitting a Hybrid turbo with 3 bar (30 PSI) of boost to a Spit as it will fall to bits very soon (although it would probably be a very exiting 5 minutes!).

The compression of the charge and other factors raise the temperature of the induction charge and pinking will be a problem at higher boost levels, not to mention your piston crowns melting apart. Intercoolers and Charge coolers are for cooling the hot forced induction charge, intercoolers use air to cool it and Charge coolers use liquid to cool the intake mixture.

A healthy but sensible 8 PSI or so should be a good bet, the rest is up to you and your wallet.

A custom supercharger installation with all kit included would probably cost at least £2000.

There are companies in the UK who do such conversions for a living.

Nitrous Oxide:

Nitrous is just an oxidising agent which when heated splits into nitrogen and oxygen, this additional oxygen can result in 50% more fuel being effectively burnt. Do the maths yourself but truly absurd power hikes can be achieved if your engine is bullet proof.

I wouldn't try it with a Spit engine.

Actually Getting Started: *The Ignition System:*

I am not a great expert in this field so I will make it short and simple as I couldn't honestly go into any more detail and claim to know what I was talking about.

Parts Prices:

- New Aldon performance tuned distributor £110
- Electronic ignition module £60>250
- Good quality silicone cored plug leads £20 a set
- Three dimensional computer ignition system £350>1000

Contact Breaker Ignition:

This is what you have now (if you haven't already fitted Electronic ignition).
When in perfect condition it can produce almost as much power as an electronic system, however it is rarely in such condition and so for consistent trouble free performance fit an electronic system.

The Distributor:

The standard Lucas one is fine but will probably require different bob weights to alter the timing in a tuned engine. Alternative weights are available at very modest cost from Triumph Tune.

Weber DCOEs and also I believe most if not all Weber DGV do not require a vacuum line to be fitted. Different distributor weights will be needed to compensate though. Do not attempt to alter a carb or manifold to accept a vacuum line where one is not required.

AC Delco distributors as fitted to earlier Spitfires are generally regarded as inferior in build quality to the Lucas unit. Unfortunately I am not aware of any alternative units to the Delco one although I have heard of US Mallory units being attached to Spitfires. Mallory are certainly superb but I don't know if they can be fitted to early or just late models of Spitfire.

Aldon Ignition in the UK do new performance tuned Lucas style replacements, I am unsure if they do one to fit the old Delco equipped engines.

Electronic System:

This works by using either magnets or optics to trigger the spark and is more accurate and can use higher voltage coils as the points wont burn up. The high voltage coil means you can open the plug gap up a little to burn the fuel slightly more effectively, not much more though. Starting will improve too especially on cold damp mornings.

Cons and Garbage Info:

- Be very careful about magic electronic gizmos that increase power by 20%. They are lying, a system called (unfortunately) a Spitfire often marketed at shows has been tested to show no measurable power gain. Many `wonderful` plug leads claim similar sort of daft power gains and I don't believe a word of it. Fit some quality cheap silicone cored leads and forget.
- There ARE many very expensive and cunning systems that can provide more power through better ignition but these are usually race car only (due to expense) and certainly don't give 20% more power!
- Those marvellous looking 4 pronged spark plugs do not increase power, they just last much longer as the spark moves onto the next prong once one has been burnt and sooted up.

Useful info:

When an engine has been modified consider fitting spark plugs with a different heat range, the rolling road will know which ones to try so bear in mind your new powerful engine may run better on different than standard plugs. Spark plugs are designed to burn off the combustion deposits at certain operating temperatures, when you alter them by tuning an engine the plugs MAY need to be changed to continue to burn off deposits and avoid sooting up.

3D Mapped Ignition Modules:

These systems alter the ignition timing based upon engine speed, throttle position and Rpm.

They can be fitted to any engine with a Weber DCOE carb as the throttle sensor bolts to it.
Most can be mapped at home on a PC and come with all kit from £350. They do provide a power advantage and more economy but again you are not talking about 20% or even 10% more power.

They often throw out the distributor and use a magnetic crank or flywheel trigger which is more accurate.

Engine Water and Oil Cooling:

Prices:

- Wide 4 row radiator £110

- Aluminium radiator £300>400
- Compete thermostatic oil cooler kit (with stainless overbraid) £110

Radiators:

The standard radiator in perfect condition is adequate for an unmodified engine, a wider one or one with 4 core channels will be what is needed for a tuned engine

Very expensive aluminium ones are available as they are lighter and dissipate heat better, at about £300 a piece you should ask yourself if you really need one though.

Fans:

The standard fan provides not much cooling at low rpm when it is needed and too much at high revs when you are getting plenty of air flow naturally. The later Viscous fan is much better but is still not as good as an electric fan mounted in front of the radiator.

The electric fan consumes much less horsepower as it is far more efficient than the mechanically driven one and is only switched on when in heavy traffic anyway.

If you don't fancy the cost, get one from virtually any modern car breakers yard and you can probably fit it.

You should chuck the old fan away now as it blows air which interferes with the suck electric fan. That will gain you up to about 4 Bhp as the engine no longer has to drive round that old fan.

The great Oil debate:

This is also a most contentious issue in classic car circles. On the one hand there are those who stick to 20/50 mineral oil and change it every 3000 miles and there are those who swear by modern synthetics like Mobil-1.

I'm not by any means a Fluid Dynamics expert and most of my attempts to locate independant trials of different oils have prooved for the most part inconclusive.

One study of New York taxis over a period of several years allegedly showed no measurable difference in engine wear between traditional Mineral oils and modern Sythetics. I cannot vouch for the validity of this study or how it was conducted but it's an interesting statement.

Several things are clear:

- The mileage covered between changes has a far greater effect upon engine condition that any kind of oil or additive
- Additives should not be used in modern Synthetics as they are factory designed to be as good as they can be.
- Several manufacturers of oil additives have lawsuits and other injunctions pending against them for false advertising claims which have not been proved in any independent testing. This includes big names like PROLONG. I think they should be avoided all together.
- Most if not all modern engine manufacturers recommend Synthetic oils in their engines.

I personally think that a good quality oil filter with an anti-drain flap valve and regular changes are the things to aim for. I shall be using Mobil-1 but as I am attempting to keep this engine trouble free wil not be doing any strip downs to check its effectiveness.

Oil coolers:

Prices:

- Oil cooler installation kit, braided hoses, filter sandwich plate, thermostat, brackets etc...£70

- 13 Row thermostatic oil cooler bare, requires kit as above..£48....(add £10 for 16 row cooler)

- Oil > Water cooler, requires fitting kit..£165...(£35 more for larger one)

An oil cooler is just a miniature water radiator but made much more robustly to handle the higher pressures.

I think oil coolers are very good and should be fitted. Basically when Triumph designed the Spit engine in the dark ages people didn't go bombing down the motorway at 90 Mph all day.

So oil getting too hot and losing its lubrication properties was not a problem, hence no oil cooler. Although it was available at some point as a factory option.

Now I know that Mobil 1 and all the rest of the modern synthetic brigade are far more tolerant of high temperatures but if that solves the problem then WHY I ask does every single modern car I have seen have an oil cooler?

Oil temperature is not greatly influenced (cooled) by water temperature, neither is engine temperature influenced by the presence of an oil cooler. It is simply fitted to ensure maximum oil film strength at all engine speeds no matter how arduous.

Also every racing car irrespective of vintage or capacity has one too.

A 13 row one is fine for road use and a 16 row one for racing.

Fit it correctly, the thermostat and cooler must be mounted as per the instructions, its very easy to get the oil flowing the wrong way round the piping.

Make sure you fit a thermostatic one as over cooling the oil will do the engine no good either.

If you posses a cooler without such a feature you can purchase thermostats that plumb into the feed lines.

Also fit a slightly stiffer oil relief valve spring (from Moss Europe) to compensate for having fitted several feet of rubber pipe into the oil system.

I strongly recommend getting stainless overbraid, I discovered my plain ones almost sawn through by chassis suspension tower rubbing.

Oil > water coolers are available but require extra water cooling capacity to cope with the additional cooling requirements. These oil>water coolers are also more expensive but useful if space is limited as they are smaller than other types of heat exchanger.

Here are some influential facts on oil coolers from the AEROQUIP/MOCAL catalogue:

1: The cooling requirement for oil rises 300% per 1000 Rpm increase.
2: All German cars are over engineered in the oil systems due to a possibility of very high speeds on the unrestricted Autobahns there
3: Fitting spoilers and other aerodynamic aids can drastically restrict the air flow over the hot oil in the sump pan
4: Oil temperatures of over 110 degrees C must be avoided.

If you are nuts or have a turbocharger you can actually get an engine pre-lubricator which pumps oil around before startup and after shut down. Its a sort of tube filled with oil, it can be mounted to any engine with an oil cooler. This is total overkill for 99% of cars but very useful on turbos as they depend on engine oil lubrication very heavily. The post shut down flow can stop them overheating. About £250 for one of these.

Actually Getting Started: *The Engine Block*

The block (an engine minus the cylinder head) is the building basis for the engine, any other mods are immaterial if this is badly or incorrectly prepared for the increased power and revs you will be gleefully subjecting it to.

Thank god the block is made of good quality cast iron and will be more than capable of handling the extra power, the crank, rods and bearings are our major concerns.

Have it chemically cleaned as per the introduction.

Demon Tweaks:

- The central main bearing oil way is the same diameter as the others in spite of the fact it provides oil to both the central con rods. You can by gently tapping out the distributor bush from the bottom of the engine drill the oil way out to 5/16". The passage is a dog leg shape and needs to be drilled both from the bottom of the central main bearing and the side of the block. You should use a thin stick to measure the length of the `legs` of the passage and put a bit of masking tape on the drill bit so you don't over cook it and bore a nice hole through the block!

Once done, very carefully and gently de burr the ends of the oilway.

Also note that the distributor bush has a bit machined out to allow oil flow, you MUST put it back in facing exactly the same way as it came out otherwise oil flow around the critical oil gallery will be compromised.

This is STRICTLY a mod for the nutter or serious racer and is undertaken totally at your own risk. More detail is available from the Triumph Official Competition Preparation Manual (available from the Triumph Sports Six Club (TSSC) in the UK).
If you don't know exactly what you are doing PLEASE DON'T DO IT!

Remember that this will create lots of mechanically lethal metal swarf, don't do it after you have just had it chemically dipped!

- If using a rocker oil feed then block off the oil feed from the rear of the block with a grub screw, tap the hole first of course. You should do the same to the cylinder head to eliminate that annoying back of head oil leak. As before this is a BEFORE cleaning operation and should under NO circumstances be undertaken with an engine not stripped totally and then taken off for cleaning. Also this is an `at your risk` one, if you want to do it but not yourself then get the engine builders to do it for you.

Other block operations:

If you are fitting new pistons you will naturally get a rebore, the final crosshatch finish is essential to enable piston ring break in and good lubrication.

The deck top should be checked to see if its dead level, it may require a minute skim, this is important to ensure a good block>head seal. Also perhaps get them to check if the deck top is parallel to the crankshaft axis. A really good outfit can fix this for you by taking a minuscule wedge shaped skim off the deck top if there is any discrepancy.

The Oil Pump:

Regardless of which Spitfire engine you use fit the alloy bodied 1500 oil pump, it is superior to earlier models (as well as a bit lighter!) It bolts straight on to all models.
Improve its performance as follows:

- Reduce end float to a minimum by carefully lapping the body on a bit of thick plate glass with 1000 grade emery paper.
- Check that the ends of the rotors are smooth and burr free to reduce the chances of them `picking up` some bits of end plate.
- Check that the new pump outlet lines up with the feed hole in the block, you never know with Triumphs!

The Sump:

For fast road use Triumph Tune recommend baffling the sump with 2 vertical plates (with some holes drilled through them) welded to the bottom of the sump (inside it!) facing left to right. Also weld (or screw in) a horizontal plate with a hole in it just big enough to let the oil pump pickup through.
These mods eliminate (almost) the problems caused by oil surge. This is basically when you take a fast long corner the oil all slops to one side of the sump and starves the pump. The same thing happens if you brake or accelerate violently.

For full competition use they also recommend increasing its capacity by cutting the bottom off the sump and welding in a 1" strip of metal all the way round. Be very careful if you do this!

If your welding isn't up to it you should be able to braze it successfully.

The Oil Filter:

As standard the oil filter slowly drains back into the sump. Better ones with anti-drain flap valves are available. Expect to pay more for these but it is worth it. This is why most sensible engines have filters mounted vertically down, consequently they don't need anti-drain valves.

Dry Sump Lubrication:

Dry Sumps: £500>1500

In a dry sump engine the oil is stored in a separate tank, there are usually three scavenge pumps that suck oil from a special sump pan. A separate external oil pump lubricates the engine. This is the ultimate way of avoiding oil surge and provides the best lubrication system.

Kits are available to suit any engine in existence if you must have it.

Don't even bother thinking about it unless your a totally mad racer or have too much money.

Choosing a Camshaft:

- What is a camshaft?

The camshaft is a crank driven shaft upon which there are several small elliptical `cams`, through the rockers these push on the valves at various predetermined intervals. This lets air in and exhaust gas out, the exact timing of these operations is critical and any change in the valve timing has a profound effect upon the behaviour of the engine.

- Why do I need a new camshaft for race or even a fast road Spitfire engine?

You don't need a new camshaft for tuning Stage 1 which will still provide you with about 15 Bhp more than standard.
Only when looking to surpass this is one required. The standard cam is well designed for providing a nice easy to drive all round engine that your Granny can still cope with (well maybe). If you are reading this you probably don't really care about 'nice all round' and would like perhaps a little more top end urge to the car.

Camshaft changing is just a compromise game, there are NO super smart cams that provide 50% more top end power AND still the same low down Torque. They don't exist and anyone who says otherwise is either lying or a bit dim.
If you want more top end the cam will give but only by sacrificing the low end Torque, the secret to choosing the cam is being realistic about what you need the car for and not going nuts.
A more radical cam simply either keeps the valves open longer, opens them further or often both.

- OK here is my list of cams, what do all these daft looking numbers actually mean in the real world?

If you get some data from the manufacturer / distributor on their cams they should supply a list of figures on each one.
These will include valve Timing, valve Lift and should also include the Power Band in Rpm of each cam.
Remember that the higher valve lifts reduce valve guide life once lift approaches about 0.29".

The figure 18-58 for example means that the inlet valve is open from 18 to 58 degrees of crankshaft rotation.

For a 1500 my personal choice and recommendation is the Fast Road 83, for a 1300 you may like the Fast Road 89 providing you have Weber carburettors. These cams will provide up to around 120 Bhp in the case of the 89 cam while not turning the car into an undriveable monster.

Below is the list of figures from the Triumph Tune list of camshafts in ascending order of top end output, I have included a short note on each for its best use. If you have an alternative camshaft supplier you can draw similar comparisons by getting similar specifications to the ones below.

I think that Triumph Tune use KENT CAMS as their supplier. PIPER also make cams for the Spitfire. KENT have a bigger selection as far as I know but PIPER cams should also be top class kit.

....................................Inlet..........Exhaust.....Valve Lift... Power Band....Max Bhp @

- Standard 1500 cam... 18-58..........58-18.......0.240" ....?...........about 4600 Rpm

- Standard Mk3 cam....22-62..........62-22........0.240"............?...........about 4800 Best standard profile

- Road 83 cam.............30-56...........74-28........0.288".......2200-5200.........4750 SU carbs or single Weber

- Fast Road 83 cam.....37-63 ....74-28........0.288" ......2500-5500.........5250 115 Bhp : Webers or 1.5 SU's

- Fast Road 89 cam.....34-76...........58-34........0.293".......2750-6250.........5750 120 Bhp : Twin Weber DCOEs

- Race 83 cam.............42-68...........74-32.......0.302"........3300-6500.........6000 Rpm, Race only

When looking at this list, go out for a normal drive. Look at the average Rpm you do and the maximum you did.
I would like to bet you didn't go above 5000 Rpm and mostly stayed at about 3500 Rpm average. Be realistic, a race cam will be terrible to drive on the roads. Imagine having to rev up to 4000 Rpm EVERY time you leave the traffic lights etc.
Fuel economy will also suffer badly from a race cam, the 83 and 89 cams can still provide 30 Mpg with twin Webers if you drive carefully. If you like the extra power they provide and really hammer it fuel economy can drop to 20 Mpg.

As a point of interest a full race Spitfire engine driven on track can get to much less than 10 Mpg!

Engine Bearings:

Bearings are designed to be softer than the rest of the engine for two reasons.

1: To let them wear out first as they are cheaper to replace than a crank
2: To let metallic particles which are encountered be imbedded in the soft bearing and so not protrude to scratch the crankshaft.

The high performance variety are harder than standard to cope with the higher stress, this makes them more susceptible to metallic particles. Lead copper ones are the best variety for this purpose and Vandervell make very good ones. Apparently these really good bearings are getting harder to find these days.

Again make sure that the oil supply holes in the bearing shells match up to the oil outlets in the bearing housings.

Be absolutely sure when installing bearings to treat them with the sort of respect you would treat a one million dollar glass vase. No scratches, no dirt and absolute precision.

Non essential (but useful) operations:

-The main bearing housings can be line bored or line honed to make sure they are absolutely dead aligned and circular. The machine shop should be able to accurately measure it up to ascertain if this is needed or not.
- The block can be machined to accept camshaft bearings if it does not have them
- The block can have the centre main bearing bolt holes bottom tapped and longer bolts fitted.

The longer bolts MUST be of the type designed for the purpose, even very high quality bolts will often not do. Grade 8 is the term often used for such bolts, I admit to being less than sure of exactly what Grade 8 means.

- Using a countersink drill, or large drill bit take the top couple of threads out of the main bearing cap bolt holes to place the stress deeper into the block.
- Use higher quality main bearing cap bolts (available from Rimmer Brothers UK)
- Polish and shot peen the main bearing caps, this will make it more difficult for cracks to start in them. To save money polish them yourself and have the shop shot peen them, a high mirror gleam is pointless as the peening will dull the finish anyway.
- If you really fancy being `super fly` you can if you are lucky persuade the shop to fit full circle thrust washers, hey presto double the bearing surface and half the wear rate. The bearings are softer than the crank so I wouldn't worry about crank wear.
- They can also `pin` the thrust washers in place to stop the old "falling out and wrecking the engine" routine.

The Crankshaft:

As with the block its good quality and on the 1300 even to 9000 Rpm the standard crank can be used providing its properly prepared, the 1500 one is fine too but if you insist on having a 1500 and trying high revs a steel billet one made from 4340 Chrome Moly steel can be made.

The only minor problem with that is that it can cost £1500 for one.

Generally do the following to the standard one to ensure no expensive bangs at high revs.

- Have it ground and the journals micro polished
- Have it Nitrided or Tuftrided to improve hardness
- Take a small fine grinding stone to the oil outlet holes in the crank and chamfer them very slightly so that the outlet opens out a little and has no sharp edges. For goodness sake don't slip now, cover the journals up with masking tape to give a little protection should the worst happen.
- Remove all rough casting flash from it and smooth off (carefully) any sharp corners
- You can have it indexed which makes sure that the crankshaft throws are identical and correct for each small end journal.
- For outright race use having the main bearing journal oilways cross drilled will provide superior lubrication at high Rpm.
- Have it balanced AFTER you perform any of the above operations! If you don't its back to the balancing shop with your crank....

Harmonic Crankshaft Damper:

I have never seen one of these made to fit a Spitfire but with a certain amount of ingenuity I'm sure one could be made to fit.

What they are: They are an addition to the front engine pulley (sometimes they are one unit with the damper having a groove for the fan belt too), they contain a sort of high viscosity liquid which somehow absorbs vibration and makes the rotation of the crank smoother. These can extend bearing life very beneficially, most V8 engines have them as standard.

For example a new one for a Chevrolet V8 is about £80.

The Flywheel:

- The purpose of the flywheel is to provide a nice point to mount the clutch, put a starter ring on, and to smooth the engine at lower rpm. To disappoint you lightening the thing will not make the car any more powerful.

- Lightening is only to make the engine spin up faster. Useful for racing or with a medium amount taken off nice for a fast road car too. The 1500 flywheel can have more taken off than the 1300 ones which require fairly minimal work. About £60 for a lightening session. This is not work to be taken lightly (sorry I couldn't resist that one), an operator who is not very clever can fatally weaken the flywheel by taking material off the wrong bits. Obviously the greatest gains are made by removing metal as close to the edge of the flywheel as possible.

- Ultra light Steel or even Aluminium ones are available for the Spitfire, these will make an idle speed of less than 1500 Rpm horribly lumpy. Hence serious race cars only, expect to pay anything up to £500 for one of these.

- To fix a flywheel on (to avoid the scary steel Frisbee effect) use ARP bolts. These are about £15 a set.
If using the standard flywheel for race use then you can also have it and the crank machined to take additional dowel pins.
Along with ARP bolts (usually of at least 200,000 PSI strength) you can look forward to a race without any low flying car parts decapitating spectators.

The Clutch:

The standard clutch should be just fine for all but a race engine, uprated ones are available for around £120 each.

Some racers have the flywheel altered to fit a Ford Escort clutch, Ford Escorts have the same gearbox input shaft spline pattern so its just a bolt on mod once the flywheel is altered. Like everything for Fords these are always dirt cheap.

Have the clutch cover plate balanced along with the crank etc. It should have been finely balanced at the factory but remember the `golden rule`. There is no guarantee that the locating dowels on the old flywheel are perfect.

The Connecting Rods:

These are fine for moderate fast road use with better con rod bolts, they are also fine for more extreme use provided you prepare them properly.

- Please don't use the standard bolts on a high output engine, it will break and better ones aren't really any more expensive.
- NEVER EVER use con rod bolts more than once, they are designed to stretch once torqued up and must be thrown out if disassembled afterwards.
- Have them checked for straightness, length between centres and ovality
- Polish lengthways the main arm (do NOT remove any more material than is necessary for a smooth finish).
- Do NOT alter in ANY way the small oil feed hole in the tip of the small end, its diameter is surprisingly critical for proper lubrication and any alterations may prove dangerous.
- Remove up to 20% from the small and big end caps
- Equalise them around the joint between big end cap and con rod.
- Have them shot peened
- Don't bother polishing any other areas of the rods
- Use UK Ford Sierra/Escort COSWORTH connecting rod bolts, they are good for 200 Bhp in their home engine so use with confidence. Also about 1/3 the price of ARP specialist hardware. Available from BURTON POWER UK @ £3.16 each.

- New forged steel ones are available from about £550 a set of four. They definitely won't snap but since the standard ones are fine for almost any application (providing they are suitably prepared) you should ask yourself why you need them.

As so often don't even entertain the thought unless you do serious racing.

There is some talk in the Triumph Preparation manual about using oversize MGB bearings for the big ends, I have never heard or seen anyone attempt it so I wouldn't like to say if it is either beneficial or advisable. Jon Wolfe (1999 TSSC Champion Spit Racer) advises to be wary of much of the contents of the Official Prep. manual. Until reliable contradictory evidence becomes apparent I wouldn't personally try it. The idea was that MGB bearings are a little wider than standard ones. The crank small ends required a special non standard diameter grind so you can't even try it for a laugh at the weekend.

The Pistons:

- Good quality AE Hepolite standard pattern pistons: £130 a set

- Forged race quality pistons: £450>600 a set

- Hypereutectic pistons: £250 a set.

The poor pistons have a terrible time, forced to be thrown up and down at high speed then heated up to high temperatures and covered in carbon.

Standard (NOT ones with split skirts which are too weak) will be fine for road use.

Forged ones are only for race use as they expand more on heating and so require bigger clearances to avoid seizure. This results in oil consumption that is just not acceptable for a road car.
The very best non forged ones are called **Hypereutectic**. This is not a brand name but refers to their structure which is sort of a half way house between forged race pistons and road ones. They are also about half way between in price too. As before only really bother with anything other than good quality standard ones if racing.

Have them balanced to within 1 gram of the lightest piston and carefully sand off any sharp edges on the crown, sharp edges heat up more easily and so can cause fuel pre-detonation.

Pistons have offset gudgeon pin bores to cut down on piston slap, they MUST be fitted the right way round in their bores. Some performance pistons have centralised gudgeon pin bores and so obviously do not have any preference to fitting.

In the BL perparation manual it states that if you bore the block out to +40 thou then standard TR6 pistons can be used. These pistons are strong and quite light too. The only problem with this is that you must have 20 thou taken off the top of each piston and have material milled off the top of the engine block. In the case of blocks with head gasket recesses this means getting the recess re-cut. I am quite dubious about this move and can't at present recommend you try it.

After you have paid for this lot I`m not entirely sure of the benefits of such a move. There are different procedures for installing these pistons in Mk3/Mk4 and 1500 blocks. If you really want to do it buy the BL Preparation Manual.

Piston Rings:

Piston rings seal the gas and control oil loss, some people have suggested removing a ring to reduce friction on a race engine. I do not in any way recommend this even for such a purpose.

You should also measure the end `gap` of the rings in the new bores before assembly as the correct gap will ensure optimum gas seal and oil control.

To do this insert the plain ring into the top of the new bore and square it by pushing it in a little with an up side down piston. Measure the gap with feeler gauges and cut with a very fine file as appropriate. Be sure to remove any sharp edges after such an operation.

Clever but very expensive piston rings are available called `Total Seal`, these claim to offer almost total seal of gas. I have no idea how good they are. I think it's about £100 for a full engine set of these rings, they <u>claim</u> a 5% power increase.

Camshaft Drive Gears & Chain:

Camshaft drive (notably in performance engines) is critical and an incorrectly fitted or a failed timing chain can slam the pistons into the valves. When this happens at 7000 Rpm I leave the rest to your imagination.

So fit a duplex timing chain, this just means it has two not one row of sprockets and needs a duplex set of gears too. You have two choices, fit the system from the TR6 engine which will be cheap (relatively) or fit a new system.

The new system has a big advantage, it has a vernier scale adjuster which means you can alter the timing to exactly where it needs to be. You cannot do this with the standard or TR systems, it is essential for 100% potential power release. The bigger chain, gears and tensioner all fit happily and snug in the standard timing chain cover.

Modern Ultra High Tech Tweaks:

- Have the valve seats machined on a `Serdi` (or similar) machine, it is so incredibly and deviously accurate that no valve lapping is needed which increases useful valve seat life by up to 100%.

- Get the pistons, valves and exhaust ports ceramic coated. This keeps the heat where it should be and increases power by up to about 5>10%.

- Have the entire engine and gearbox cryogenically supercooled in a computer controlled liquid nitrogen freezer. It is an advanced form of treatment which has a very similar outcome to heat treating (except you don't get distortion). It increases material strength and wear resistance by a high level. Used by top NASCAR and F1 teams the technique was pioneered in WW2 in aero engines (wasn't it all?) but proved difficult as the accurate computer control of temperature drop and rise was not available. The liquid nitrogen does not actually contact the parts but just cools them slowly and at a set rate.
For the metallurgists it converts an Austenitic structure to a Martensitic structure which is considerably harder. I was concerned about this as a Martensitic structure is also more brittle than the more malleable Austenitic structure. I called company and after a long chat and the requested press clippings I was a believer. Beware that the components to be treated must be totally dismantled first.

- Electric computer controlled water pumps, these lightweight pumps allow you to chuck out the water pump and its housing too if you can do a little fabrication. The flow is controlled by a computer which keeps the water at optimum temperature at all times. Less weight, less Bhp loss and more efficiency.

Final Tips & Techniques For Putting it All Together:

You will need the tools mentioned at the beginning, you do not NEED three Micrometers, a good quality Vernier Caliper and a Dial gauge with magnetic stands are must haves. You use the internal measurement telescopic gauges by measuring them externally with the Vernier calipers or Micrometers. You don't want to know how much internal Micrometers cost.

- First just follow the procedures in the Haynes or Workshop manual
- Have everything laid out on a clean surface in a methodical manner with associated components grouped together
- Always use new con-rod and main bearing cap bolts
- If you need any other small fixings use `S` grade ones, there will be a little `s` stamped on the top of the bolt. Do NOT use any bolts on the car which are unmarked. They are probably just old cooking pots melted down. Even ones with other markings such a `R` or `L` may have too little or too much tensile strength and should be avoided as their correct torque levels are different.

- Washers should never be used on high tension fasteners unless they are purpose made ones specified by the manufacturer, most washers will compress as it will be softer than the bolt, this can ruin the torque setting which is absolutely essential for it to resist failure or unscrewing itself. Very occasionally on things like driveshafts washers are used. These are specially made hardened ones and only these special items should be used.
Some manuals suggest the use of locking tabs on camshaft bolts and others to keep bolts from coming undone. I would not use these for the reason above, if you torque them correctly they will not loosen. Use thread locking compound if you must be sure.

- When inserting the cylinder head studs into the block they only require to be screwed in tightly by hand. Do not screw them in really really tight with mole grips or the like.

- Make sure all threads are clean and very lightly oiled, do not squirt oil down threaded holes before screwing bolts into them as the hydraulic pressure of the compressed oil will give false torque readings and may render the bolt impossible to fully tighten.

- For ultra critical bolts: Camshaft sprocket, Main Bearing caps, Con-Rods. Special thread lubricant can be used. This is formulated especially to give as accurate a torque setting as is possible. If purchasing anything by ARP they supply a small sachet of it for you with the bolts.

Do not bother with this for any other fittings

- Remember there is no point having the block cleaned if you put dirty bits into it!
Make sure the threads of fasteners are clean too. If all the little bolts are very dirty just buy new ones. Also clean your tools you will be using to assemble the engine. Gritty old socket sets mean back to the chem dip again if you use the dirty things on that nice shiny block!

When putting on the carbs etc. cover the intakes too.

- Cling film is wonderful stuff for keeping clean things free of dust and other garbage.
It seems to be unaffected by oil too! Wrap things up in it if you intend to delay the assembly.

- Always use new timing chain & tensioner, new bearings, new oil seals, new pistons and new piston rings.

Unlike steel items aluminium pistons have a limited lifespan (even if not worn beyond tolerance) as aluminium is weakened by cyclic stress badly. Lower mileage used pistons in very good condition may well still be ok if you use new rings.

The very strong aerospace grades of aluminium are particularly badly effected and can be reduced to HALF their initial strength after about 10 million stress cycles. This is why dragsters with lightweight aluminium Con-Rods replace them after every few power runs.

- Before chem dipping a block get a very fine file and gently round off any sharp machined edges. Do not take off lots of metal just de-burr it. Don't go near the bearing housings though. This will help prevent minute bits breaking off during assembly and running. It will also help you avoid cutting yourself!

- When handling the new crank tape on the old bearings to the shiny journals (clean them up though first!). This will protect the bearing surfaces, it is a law of nature that you WILL dent or scratch the journals during assembly.

- Don't over tighten the sump bolts as the ones that go into the alloy oil seal housing strip easily.

- If you are having a problem don't go the standard (and usually very effective) route of screaming with rage and heaving that little miscellaneous B****R into place whether it likes it or not. Sit back and have a cup of tea, the answer will come to you!

- When buying fasteners (except con rod, crank, flywheel & camshaft bolts) buy them from a fastener company, they are MUCH cheaper and usually better than ones from Classic car parts suppliers. Get zinc plated ones, the exception to this rule is than for really high strength bolts get plain un-plated ones. The galvanising very slightly reduces their strength.

- Having put the crankshaft in (without the con rods attached) rotate it, if you detect any stiff spots something is wrong and you MUST rectify this before proceeding. The most likely cause is that you have put one or more of the main bearing caps in the wrong place

They are numbered with little dots but I would make a careful note of which one goes where before you disassemble them in the beginning. The factory markings may be wrong!

If depressingly this is not the solution then you may need professional assistance. You can ascertain if the crank is bent with your dial gauge and magnetic stand, remove the central bearing cap and place the dial gauge feeler onto the crank bearing surface (a little to the side or the oil feed hole will foul it). Rotate the crank and watch the dial gauge, any noticeable movement and you have a bent crank. Thank god that a pro engine repair man can fix this permanently providing the crank does not resemble a banana!

This exercise can be carried out on the other two main journals making sure that the other two bearing caps are in place at the time.

- You MUST use special camshaft assembly lube on the cam lobes or the initial run will totally screw them up.

- I use it also in all the bearings in the engine to protect on initial start up. Do NOT use it on the pistons or bores as it may well stop the piston rings seating correctly.

Checking The Pulley Timing Marks:

-Note: Always turn the Crankshaft clockwise when facing the Pulley nut.
You should use the dial gauge, timing disc, and vernier scale on the special camshaft sprocket (if you've bought one that is!). The Timing disc is bolted to the crankshaft end, the dial gauge is used first to check the factory mark on the pulley for engine TDC. Top Dead Centre.

This just means that number 1 piston (the one at the front) is at the very top of its travel.
You should check this. I suggest you put that big socket onto the pulley nut and adjust the crank with a big ratchet or bar. This will be more accurate than trying to turn the crank by hand.

- Turn the crank so that the No1 piston (I shall henceforth refer to No1 Piston just as the Piston) is roughly just a little before the top of its travel.

- Put the dial gauge feeler onto the piston crown

- Turn the crank JUST enough so that the dial gauge stops moving when the crank is still turning.

- Make a small mark on the Pulley

- Turn the crank JUST enough so that the dial gauge just starts moving again

- Make another small mark on the Pulley

- The point exactly in between these two marks is TDC. If this is different from the factory mark then make a new bigger one in the correct place.

- I suggest you do the initial operation twice to be sure, it gets confusing if there end up being half a dozen timing marks! Also it will make the camshaft timing impossible.

Timing The Camshaft:

Now that TDC has been checked we can degree the cam. This optimises power and ensures maximum efficiency.

You will need the set up as per the previous operation.

The camshaft should be supplied with data for timing, this will tell you when maximum valve lift takes place. You may need some sort of short dummy push rod as the Dial Gauge feeler needs to rest on the cam follower.

The cam lobe you take the readings from may vary so check with the instructions first.

- Make sure the cam follower you use and its little bore is dry and free of oil during this operation, the oil can make it `stick` at the top of its travel and give false readings.
Perhaps have a friend gently apply finger pressure to the follower so it follows the profile of the camshaft lobe accurately.

- Put the Crankshaft degree timing disc on the crankshaft.

- Put the dial gauge onto the appropriate cam lobe follower

- Turn the crankshaft to the exact degree of rotation supposed to supply maximum valve lift to that particular valve. While doing this look at the Dial Gauge, it should peak at exactly the point the crank reaches the indicated degree of rotation.

- If it does not then use the vernier adjustment on the camshaft sprocket to turn the cam (while the crank is fixed at the same point) to alter the valve lift to its maximum as indicated by the Dial Gauge.

- Tighten it all up, congratulations the cam is correctly degreed!

Checking Rocker Geometry:

This is a must and a definite must do after a compression ratio change.
This operation should be done with the engine complete, rocker arm clearances set and engine in final specification.

- Apply a little engineers blue marker dye to the top of the valve stems.

- Rotate the engine (clockwise remember!) one full rotation

- Remove the rockers

- Look at the marks made by the dye marker on the valve tip.

- If there has been rocker>valve contact in the middle of the tip you have a correctly adjusted engine

- If the contact is towards the carburettor side of the engine then you must shorten rocker pedestals and/or push rods too. Wear on this side will cause premature valve guide failure

- If the wear is towards the other side of the engine you should fit pedestal spacers and/or longer push rods.

On this side if the marks are only just off centre then it should be OK to leave alone.

Appendix of Interesting (or at least useful) Information:

Bolt Specifications:

These are placed in ascending order of strength
All markings will be made on the top of the bolt & sometimes on the nut too.
Never ever use plain bolts for anything other than garden furniture.

Imperial Bolts:
A
R
S Minimum standard for general fixings
X

Metric Bolts:
8.8 Minimum standard for general fixings
10.9
12.9

Metal Myths:

- Titanium is NOT any stronger than alloy steel, it is just half the weight.

- Even Aerospace grade aluminium alloys are no stronger than good steel, they're much more brittle too and are not weldable (unless you have a laser welding robot in your garage).

- Stainless steel is not 100% immune from corrosion its just much more resistant than normal steels.

- ALL steels no matter how exotic exhibit the SAME stiffness values. Only the strength changes.

Stainless, Molybdenum, Nickel alloy steel, etc.: all the same stiffness.

Strange But True Pointless Facts:

- A bolt made of Beryllium will FLOAT in salt water!

- Spruce wood exhibits a superior strength to weight ratio than alloy steel!

Example Engine Specifications: All power figures are at the Flywheel and are approximate

<u>Stage 1: 85 Bhp</u>

- K&N air filters
- 4-2-1 Tubular exhaust system with straight through silencers (don't bother having a radio after getting these!)
- Richer Carb needles

Stage 2: 90 Bhp

- K&N air filters
- 4-2-1 Exhaust
- Richer still carb needles
- Electronic Ignition
- Oil cooler
- Wide radiator
- Mild head flow work

Stage 3: 110 Bhp

- All the above
- Lightened flywheel (just makes it rev up faster)
- Fully Balanced internals
- Uprated con rod bolts with polished rods
- Triumph Tune Fast road 83 camshaft
- Compression > 9.75/1
- Triumph Tune stainless steel valves, bigger 1.475" inlets with standard size exhaust valves
- Bronze valve guides
- Flowed head
- Slightly stiffer valve springs
- Three angle valve seats

Stage 4: 120 Bhp+

- All the above
- Nitrided crankshaft (wears less)
- Performance bearings
- Fast road 89 camshaft
- Vernier duplex timing chain & sprockets
- Twin Weber 40DCOE carburettors
- Exhaust wrap
- ARP flywheel bolts
- Drilled crank & flywheel for additional fasteners
- Lightened & nitrided cam followers
- Chrome moly push rods
- Roller rockers
- Bigger exhaust valves

Many parts and operations can be swapped from stage to stage and these are just a guide to give you an idea about what you might like to do. Triumph Tune lay out the general procedure as follows.

- Exhaust system
- Carburation improved or changed
- Modified cylinder head
- Performance camshaft

My 1536cc Engine

Here is the current spec of my 1500 engine: 110 Bhp @ the flywheel (before the Webers!)
110 Mph max (before I chickened out, but probably the max anyway)
0-60 in about 7.8 seconds (partially also due to drastic car diet scheme which shaved off 60Kg)

Head:
- Fully gas flowed
- Stainless valves, bigger inlets with standard size exhaust valves
- Bronze valve guides
- Stiffer valve springs
- Alloy valve caps
- Serdi machined triple angle valve seats
- Stainless 4-2-1 Exhaust system
- Twin Weber 40DCOE carburettors (about to fit them so haven't got the new power figures)
- K&N air filter
- Cool air filter box (will have soon anyway)

Ignition, Oil & Water systems:
- Electronic ignition
- Silicone cored leads
- 13 row thermostatic oil cooler
- Full width radiator
- Electric fan
- Viscous coupling & fan removed

Short Block:
-AE Hepolite +40 thou pistons
- Polished, lightened & shot peened rods with Cosworth bolts
- Tuftrided crankshaft
- Lead copper bearings
- Uprated main bearing cap bolts
- Bottom tapped main bearing cap bolt holes, top 2 threads removed
- Centre main oilway drilled out to 5/16"
- Fully dynamically balanced
- Pistons & rods balanced
- Lightened flywheel with ARP bolts
- Fast road 83 camshaft
- Lightened & tufrided cam followers
- Duplex vernier timing chain

Bibliography and Helpful Persons:

At this time most of the below companies have web sites, all books are available from Amazon.Com and the people below can be contacted for a chat & help through their workplace.

People & companies:

Mark Field of Jigsaw Racing Services: In TTG supplier list

Terry Hurrell of Triumph Tune: Tel: 0208 867 2025

Gower & Lee: carburettor specialists

Frozen Solid: Cryogenic tempering Suffolk UK: Tel: 01449 674 914 (£600 for engine & gearbox)

EMS Engine Machining Services Web: WWW.ENGINE-MACHINING-SERVICES.CO.UK

CES Power Buckingham UK: Tel: 01280 815 333 Web: WWW.RACECAR.CO.UK/CES800/

Books & Publications:

Moss Europe: Triumph Tune Performance Manual
Jon Wolfe: The Guide To Modifying Your Triumph Spitfire
BL: Official Competition Preparation Manual & Repair Operations Manual
Graham Robison: Triumph Spitfire & GT6 File
Des Hammill: How to blueprint & build a 4 cylinder short block for high performance
Allan Staniforth: Race & Rally Car Source Book
David Hardcastle: Tuning Rover V8 engines
Haynes: Weber Carburettors & Spitfire Workshop Manual
David Vizard: Theory & Practise of Cylinder Head modification
David Vizard: How to Build Horsepower (volumes 1 & 2)
Larry Atherton: Desktop Dynos, Using computers to build & test engines
Kelsey Publishing: Practical Classics, Spitfire Restoration
SA Design: Engine Blueprinting, Practical Methods for Race & Rebuild
Race Car Magazine
Cars & Car Conversions Magazine
Forbes Aird: The Racers Encyclopedia of Metals, Fibers & Materials

Places to Buy The Parts Mentioned in The Guide:

- Rover V8 Engines: RPI ENGINEERING

- American V8 Engines: REAL STEEL

- Used Weber carbs: Back of MOTORING NEWS Weekly paper

- New Weber carbs, Exhaust wrap, Air filters, ARP Fasteners and MUCH more besides: RALLY DESIGN (in TTG Suppliers guide)

- Roller Rockers, chrome moly push rods, rocker pedestal spacers, vernier duplex timing chains, fast road camshafts,
manifolds (inlet & exhaust), ignition components, Stainless valves, Valve springs, guides etc. etc.
TRIUMPH TUNE (of Moss Europe)

- Weber & SU Carb parts & rebuild service: GOWER & LEE, CARBURETTOR SPECIALISTS

- Many other bits: JIGSAW RACING SERVICES

- Head gas flow work: CES POWER,
THE CYLINDER HEAD SHOP Web: WWW.THECYLINDERHEADSHOP.CO.UK

Please. Always wear your seatbelt while driving -- and that goes double for your children if you have any.