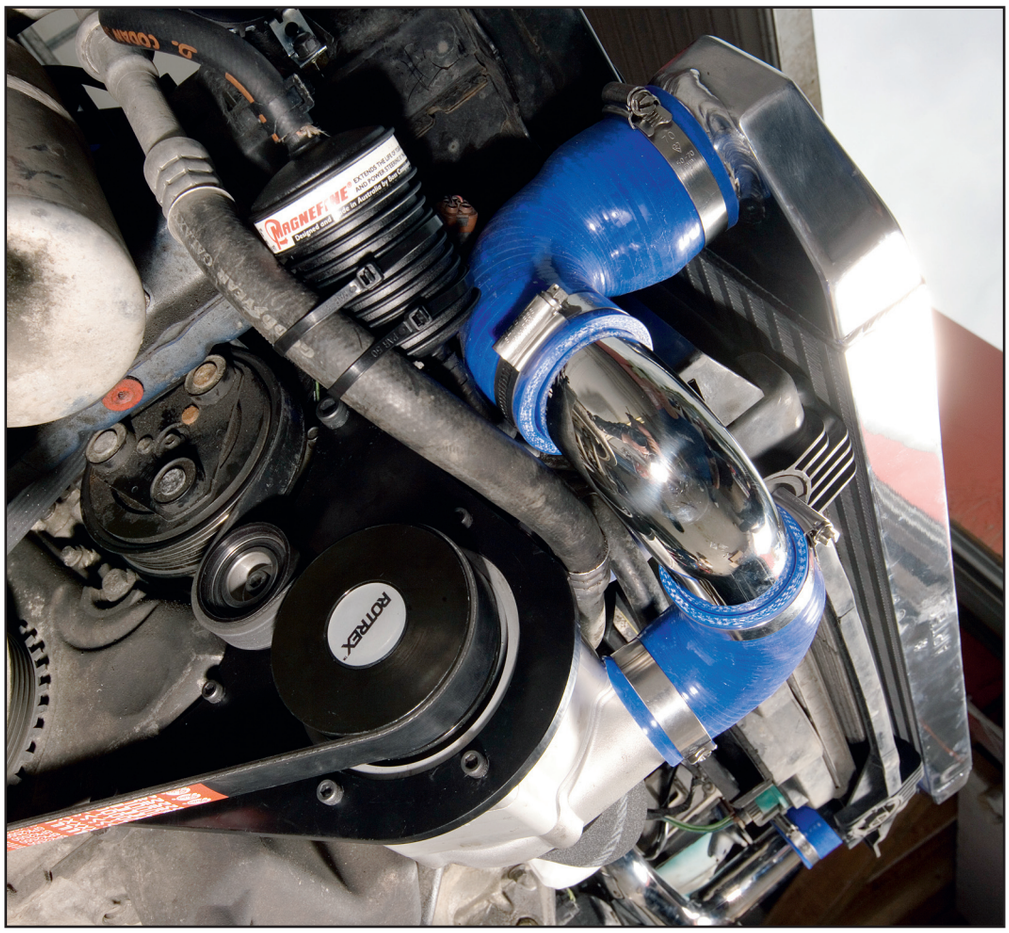
TURBOCHARGE VS SUPERCHAR

A TURBOCHARGER IS A TYPE OF SUPERCHARGER, BUT HOW DO THEY WORK? WE TAKE A LOOK AT THE SIMILARITIES, THE DIFFERENCES, AND EVERYTHING ELSE YOU NEED TO KNOW.

Forced induction has been the order of the day in recent issues; specifically we have been looking at wastegates and forms of boost control. This time we're going to investigate superchargers and how they differ from turbochargers.

Before we start though, let's look at what we actually use turbochargers and superchargers for. Well, a turbocharger is really a type of supercharger, and they are both used to force air into the engine's inlet side, cramming more air than usual into the combustion chamber so that when the correct amount of fuel is added and ignited, the resultcan be a huge power output from a relatively small engine capacity. However, they go about it differently. Both types of forced induction have good and bad points, and we will take a look at those as we go along.

Firstly, we'll take a brief look at how turbos work to refresh your memories, but this feature will concentrate on how superchargers go about their business and what's involved in supercharging your Ford. Let's get cracking...



THE EXPERT **STEWART SANDERSON**

Having worked as a tuner for over 20 years, Stewart 'Stu' Sanderson is one of the most-respected names in the business.

A Level 5-trained fuel-injection technician, Stu has worked for a Ford Rallye Sport dealer, a well-known fuel-injection specialist and various tuning companies.

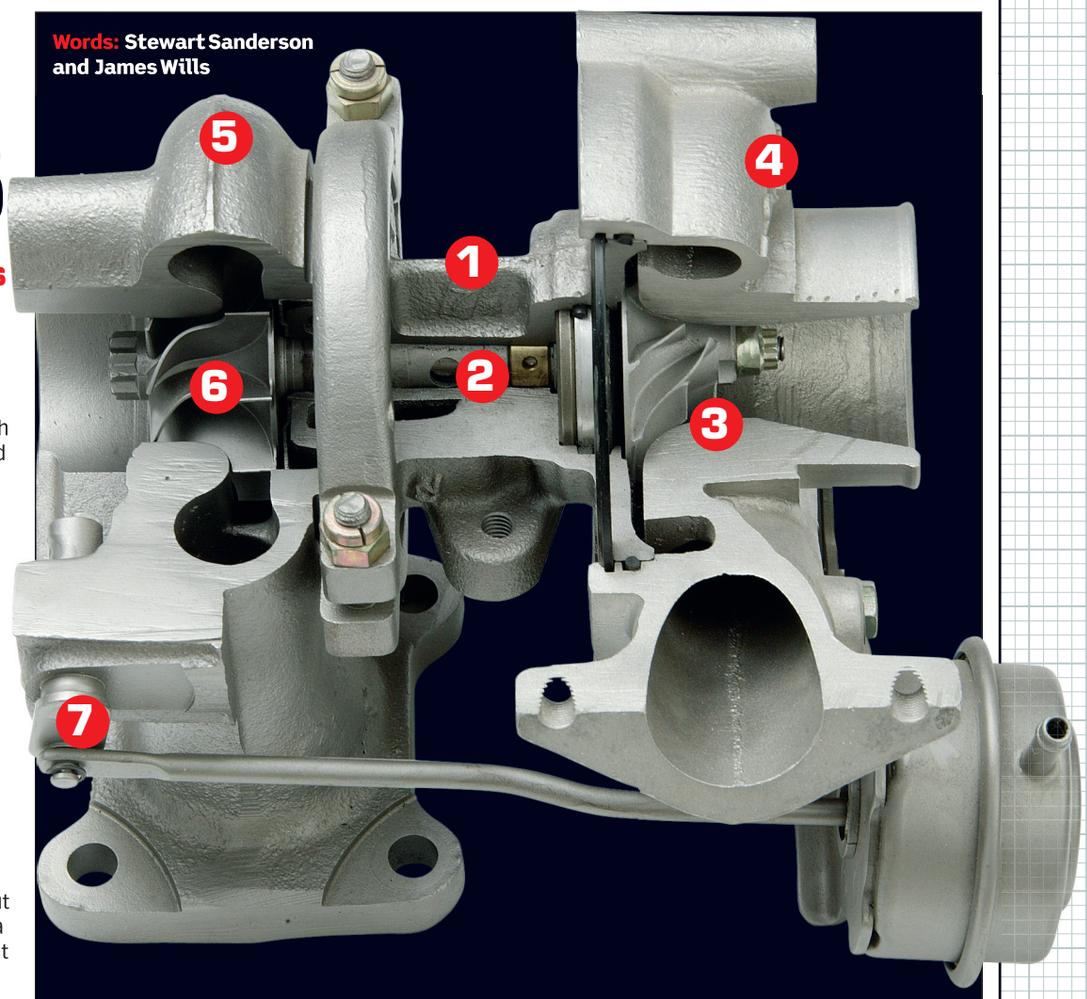
11 years ago he joined forces with Kenny Walker and opened up Motorsport Developments near Blackpool (01253 508400, www.remapping.co.uk), specialising in engine management live remapping, as well as developing a range of Evolution chips which are now sold all over the world.

He is the creator and administrator of www.passionford.com, which he started in 2003. It has grown rapidly from a few friends contributing, to one of the biggest Ford communities on the web.

Stu's enviable knowledge of the workings of modern-day Ford performance engines means that every month he's just the man to explain how and why things work, and importantly how they can be improved.

RS GERS

Words: Stewart Sanderson and James Wills



HOW A TURBO WORKS

The turbocharger is mounted on the exhaust manifold of the engine and is fed with exhaust gasses. As exhaust gasses are expelled from the exhaust ports of the engine, they travel through the exhaust manifold and are fed into the turbine housing of the turbocharger. Here the gasses have two possible paths to take, either through the wastegate if it is open, or if the gate is closed the gasses must travel through the exhaust turbine, which in turn rotates.

The compressor wheel is in turn rotated as it is also attached to the main shaft, as the compressor wheel rotates it draws air from the air filter and compresses it before forcing it towards the inlet. If the turbocharger had no form of boost control, the cycle of making boost would soon get out of control! This is why we need a wastegate – and we covered that in issue 305.

The speed at which turbochargers rotate during normal operation is shocking. Around 200,000rpm is a fairly normal operating speed for a modern turbocharger!

So you can see why the main shaft has to have a good oil feed to allow the shaft to float on oil and prevent wear, but it is also important to note how vital it is that the shaft and both wheels are very well balanced! Any tiny vibration at that sort of speed will see the turbocharger self destruct in seconds!

The turbocharger's main downfall is the fact it restricts engine power output. Yes, that's right, it restricts power output. The fact the turbocharger is part of the exhaust system, and exhaust gasses are forced to flow though it, actually causes a huge restriction in the exhaust itself. This is why turbocharged engine exhausts get so hot so fast and can be seen glowing at night. They waste a lot of energy to heat.

The turbocharger is made up of seven basic components: let's take a look at them.

1 THE CORE

Always lubricated by oil and usually cooled by water, the core is the centre of the turbocharger that houses the shaft bearings and the thrust bearings. Between those bearings, they hold the shaft in position and allow it to rotate at extremely high speed.

2 MAIN SHAFT

The main shaft is the shaft that runs right through the core and has a wheel on each end: the compressor at the cold end and the turbine at the hot.

3 THE COMPRESSOR WHEEL

The compressor wheel is a work of art to look at – this is the component that rotates at very high speed, draws air into its nose – the inducer – from the air filter and then compresses it and sends it back out from the rear of the wheel – the exducer – towards the engine's inlet.

4 COMPRESSOR HOUSING

The compressor housing actually houses the compressor wheel and completes the compressor/pump side of the turbocharger. It physically enables us to pipe air into the compressor from the air filter and creates an outlet from the compressor wheel to the engine's inlet.

5 TURBINE HOUSING

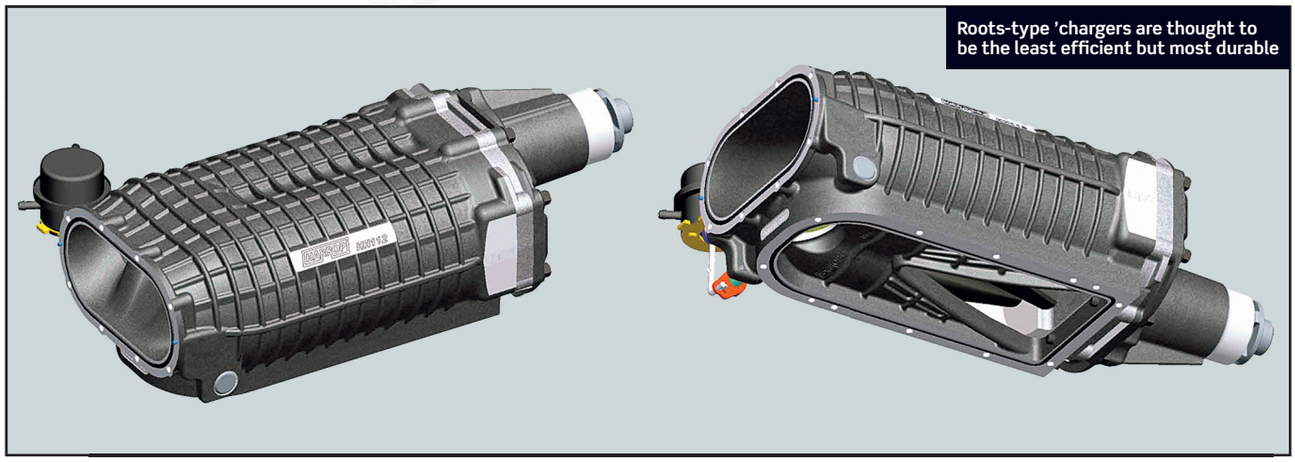
The turbine housing is, as its name suggests, the housing for the turbine wheel. It's also the component that bolts to the exhaust manifold and directs the exhaust gas towards the turbine wheel to force its rotation.

6 TURBINE WHEEL

The turbine wheel is the component that is driven by the exhaust gas. This wheel is the one that has all the rotational energy and it is bolted to the main shaft, thus enabling it to also turn the compressor wheel which is connected to the other end of the main shaft.

7 WASTEGATE UNIT

These are either internal or external but all do the same job, they allow us to let exhaust gas bypass the exhaust turbine wheel, thus slowing the turbocharger and limiting boost pressure.



Roots-type 'chargers are thought to be the least efficient but most durable

SO, WHAT'S A SUPERCHARGER?

The supercharger is very similar in principle to the turbo as it pumps air into the engine via a form of compressor, of which there are three main types, but the big difference between these and turbochargers is that the compressor is not driven by exhaust gasses.

The compressor unit on a supercharger is driven by a belt, running from the engine itself. This means the supercharger's speed is determined by engine rpm, so really it doesn't need a wastegate or boost control, as the boost can be controlled by rpm and gearing, and will be the same every time. It also means to create more boost we just change the ratio of the pulleys driving it so that it spins faster or slower, exactly like changing gears on a pushbike.

WHAT ARE THE PROS OF A SUPERCHARGER?

The exhaust system on a supercharged car can remain free-flowing which allows the engine to act more like a normally-aspirated engine. This is why supercharger conversions are more common to a normally-aspirated engine as the conversion is a lot simpler and cheaper to achieve with no expensive and complex exhaust manifold modifications to be made. They are also more efficient as a rule, so smaller intercoolers can usually be utilised, or often none at all.

AND THE DOWNSIDES?

Driving the compressor via a belt does have its drawbacks. The power taken to drive some superchargers can, in extreme cases, be as high as over 100bhp just to drive the supercharger! So it is vital the correct type and gearing of supercharger is used in your application! Also size can be a drawback: some of the bigger superchargers simply will not fit under your average bonnet as fans of American drag racing (where superchargers standing proud of the bonnet are commonplace) will testify!

SUPERCHARGER TYPES

There are three different types of supercharger in common use today and the main difference between them is the type of compressor being used. These are centrifugal, twin-screw, and Roots-type. The Roots-type is often called an external compression pump because no compression of air actually takes place inside the 'charger's case. This is the key point of difference between the Roots, centrifugal, and screw-type blowers. Centrifugal and screw-type are considered to be internal compression superchargers because the impellers in each unit actually compress the air inside the supercharger unit itself, and then send the compressed air to the engine's intake manifold. Air is trapped between the rotating lobes and the casing in which they ride and is forced around from inlet to outlet.

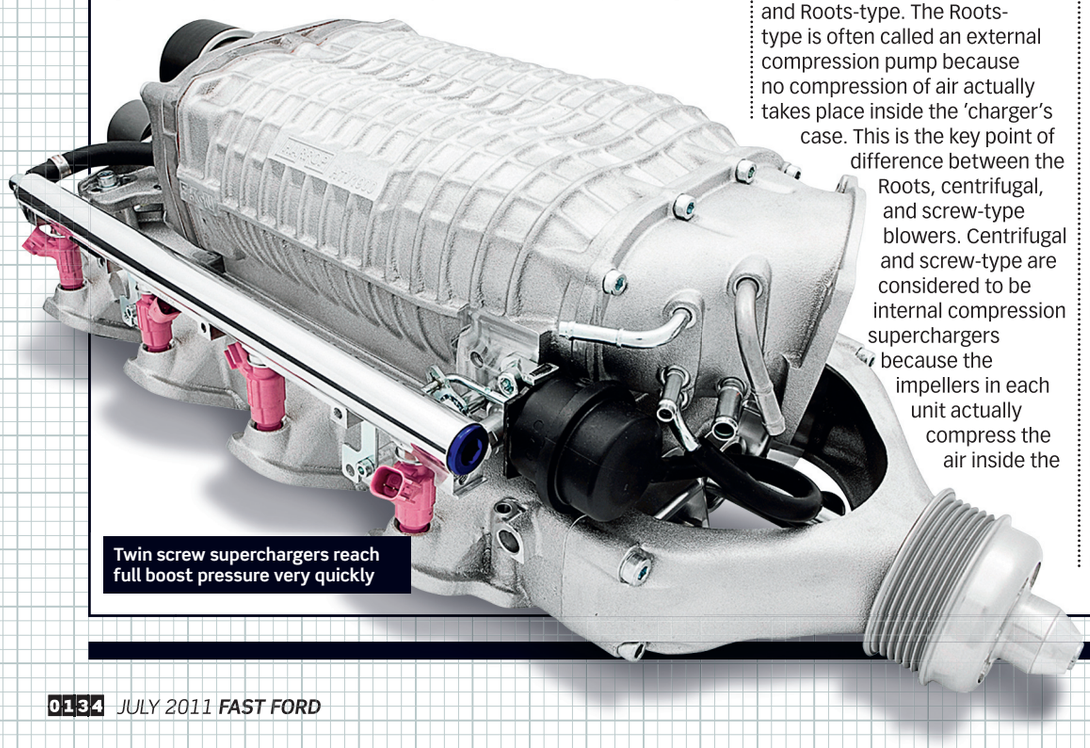
TWIN-SCREW SUPERCHARGER

The twin-screw design was developed to fill the void between centrifugal and Roots type superchargers. It is a positive displacement unit, which means it moves a fixed amount of air per revolution, like the Roots type 'charger.

"THE SUPERCHARGER'S SPEED IS DETERMINED BY ENGINE RPM, SO IT DOESN'T NEED BOOST CONTROL."

Unlike the Roots, which is only an air delivery system, the twin-screw supercharger is also a compressor. The counter rotating lobes and chambers of the twin-screw are designed for a screw-like tapering effect running intake air into a smaller space for output, thus compressing it. The rotors have very close tolerances yet never touch. Compressed air is delivered into the engines intake system with very little leakage or energy loss.

The twin-screw supercharger creates boost the instant the throttle is touched, and generally reaches full boost very quickly indeed. Full boost is then available all the way to redline. A positive displacement compressor is ideal for road cars and because of the increased mechanical efficiencies of the



Twin screw superchargers reach full boost pressure very quickly

superior design, the output air temperatures of the twin screw positive displacement supercharger are radically improved from the Roots-type and often produce an adiabatic efficiency in the 70 to 80 percent range across the whole power band which is incredibly efficient.

ROOTS-TYPE SUPERCHARGER

The Roots-type supercharger is a positive displacement device that consists of two counter rotating meshed rotors. The two rotors trap air in the gaps between their rotors and push it against the compressor housing as they spin toward the outlet port.

Most superchargers are typically driven directly from the engine's crankshaft via a belt but in order for the Roots supercharger to deliver air at greater pressure than atmospheric, it has got to be geared so that it spins a lot faster than the engine. Out of the three basic supercharger types, the Roots are considered the least efficient. The external compression nature of the Roots pump creates more heat in the inlet air charge than the internal compression centrifugal blower does so any air from a Roots supercharger will typically be less dense than the air from a centrifugal blower, so you will make more bhp with 1psi from a centrifugal, than you will a Roots.

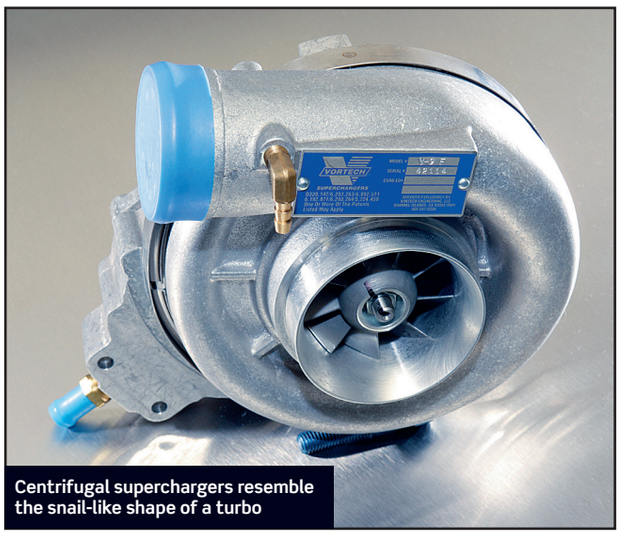
Its upside however is its ability to produce a decent amount of boost while spinning at relatively low speeds. This makes it ideal for use on smaller engines that traditionally struggle in the lower-half of the rpm range.

Another benefit of the Roots-type supercharger is the simplicity of its design. It has very few moving parts and spins at relatively low rpm, making it one of the more reliable and durable supercharger designs.

CENTRIFUGAL SUPERCHARGER

The centrifugal supercharger's compressor creates its boost in a very similar way to a turbocharger. It has a compressor with an inducer that draws air into the centre of the compressor. Many centrifugal blowers have a round, snail-like case that resembles a turbo.

After drawing the air into the centre of the compressor, it throws the air outward into the scroll. The scroll acts as a chamber to collect the air molecules and channel them toward the discharge tube so that they can be forced into the engine's air intake. The diameter of the scroll increases as it moves further away from the centre of the supercharger, which slows the flow of the air while increasing its pressure. This compression method allows the centrifugal supercharger to produce a fairly high degree of thermal efficiency.



Centrifugal superchargers resemble the snail-like shape of a turbo

However, in order to generate substantial amounts of boost, the impeller must spin at very high rpm. The amount of boost produced by a centrifugal supercharger is proportional to the square of its impeller speed, enabling the centrifugal supercharger to make a substantial amount of boost in the upper half of the engine's power band.

WHICH IS BEST?

I hope that from reading this article you'll be able to see the main differences between these two forced induction types – the turbocharger is being driven by exhaust gas and is mounted on the exhaust itself and also its power is not free! It causes a restriction in the exhaust system which causes the engine to lose power before the turbo's boost pressure can overcome that loss.

Whereas the supercharger is belt driven and mounted on the engine itself so much easier to install, but it also takes power from the engine to run it and some units are just as laggy as a turbocharger. The job of the two remains the same though, simply to pump air into the engine under pressure.

As for which is best, it is personal preference really, I personally love the way a turbocharger can produce large power on a relatively small engine with only a small amount of space taken up, and I also love the way that power is created. But in order to run big power you do have to put up with the turbocharger's downsides! You can't have your cake and eat it...

Superchargers still have a lot going for them and they can make a really nice driving road car, indeed manufacturers are still making good cars with them such as the BMW Mini Cooper S. Maybe a good solution would be to use both!

So next month let's look at just that, compound charging... using turbochargers and superchargers on the same engine.


Roots 'chargers suit small capacity engines which struggle at low rpm

NEXT MONTH
COMPOUND CHARGING – SUPERCHARGER AND TURBO IN TANDEM