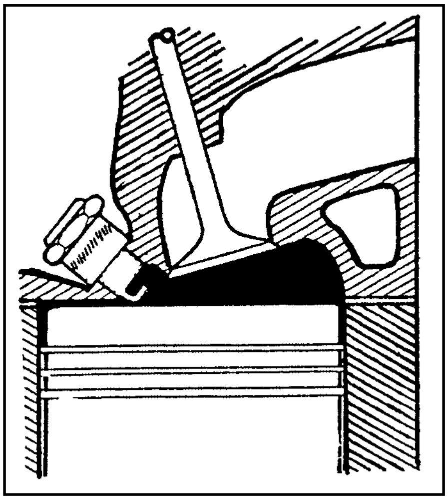
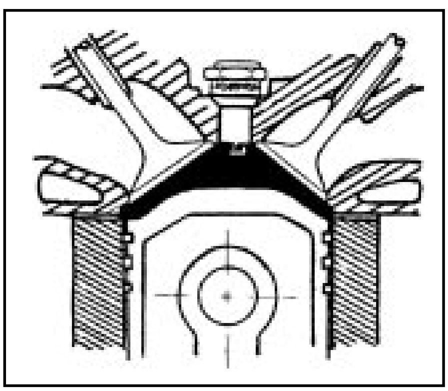
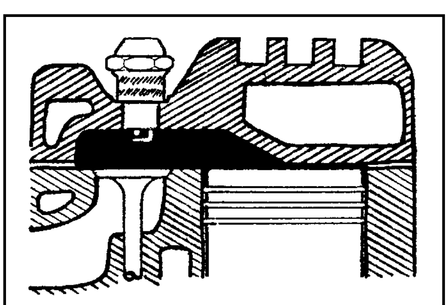


Wedge head.



Hemi head.

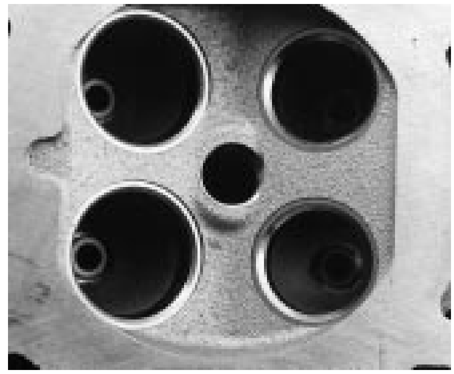


Sidevalve.

sloping sided combustion chamber. Increasingly used for modern four valve per cylinder layouts.

Hemi - The valve heads are opposed, as above, but the chamber is hemispherical.

L-type or flathead - An older



Pent- roof four valve per cylinder chamber.

design used for engines with the valves contained within the cylinder block (sidevalves).

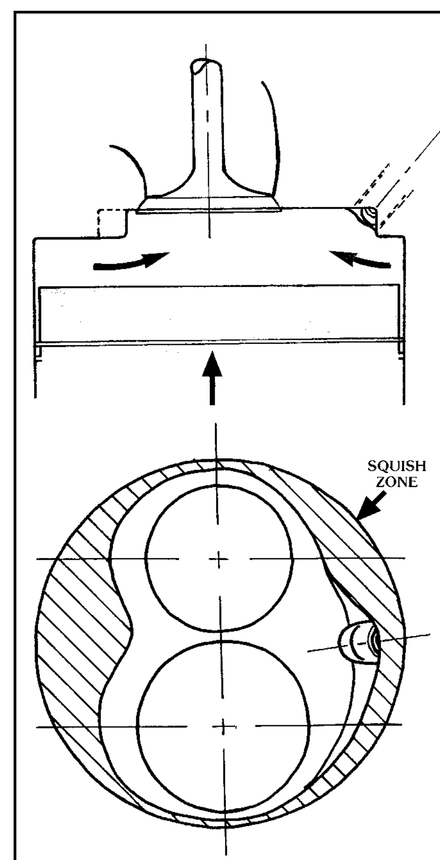
SQUISH

'Squish' is the descriptive name given to the random movement of the yet unburned air and fuel mixture in the cylinder, caused by the piston nearing the cylinder head towards the end of the compression stroke. In most cases, a part of the piston crown and the cylinder head get pretty close to one another at Top Dead Centre (TDC), approaching at fairly high speed. Mixture caught between these rapidly closing surfaces is 'squished' or squirted out of the way. The easiest avenue of escape is into the main body of the mixture already contained within the combustion chamber, resulting in a useful increase in the movement of this fresh charge. The majority of the mixture is now confined to the combustion chamber in preparation for the ignition spark. This random, turbulent movement generated in the chamber helps the air and fuel further mix together, resulting in more complete combustion.

SWIRL (& TUMBLE)

'Swirl' is the name for the organised movement of the air/fuel mixture in the cylinder. It is becoming an increasingly common feature of cylinder heads on modern engines as manufacturers strive to maintain or improve power outputs, whilst reducing fuel consumption and emissions. As with squish, swirl is used as an additional technique to improve the mixing of air and fuel, and help promote more complete combustion.

Swirl can be created by using the port design to direct the incoming mixture. The port can be either curved smoothly to direct the flow past the valve, or have a hump or deflector in it to force the flow out one way at the last minute, so to speak. The incoming



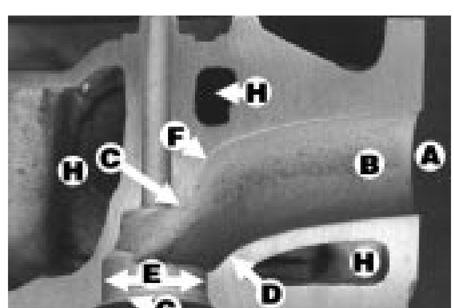
Schematic of how piston motion generates squish in a typical 'bathtub' chamber.

Chapter 7
Modification work

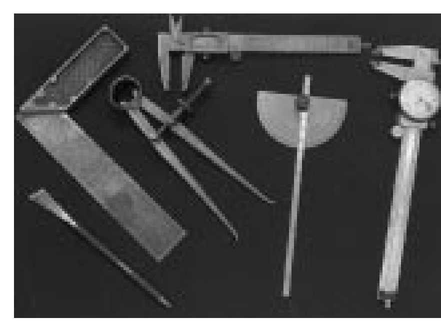
PORTING

When porting cast iron, use the carbides first for most of the major metal removal, then follow with the stones. The process for aluminium heads skips the stoning stage as the material clogs the stone. **Caution!** - Keep the carbide/stone moving **at all times**. Leaving it too long in any one place will create a hollow that will have to be removed. If you're not careful you could end up chasing hollows all around the port and finish up with a mess: moderate pressure on the stone is all that's needed - and keeping it moving. Stop frequently to check progress by running a finger around the port. With a little practice the bumps, hollows and general imperfections will become apparent. The tricky bit is removing/smoothing/blending these without creating further problems for yourself. Work **carefully** and check **frequently**! To begin with, it's best to err on the conservative side, by just refining the existing port contours. Aim to remove any obvious imperfections and get a smooth port that is round or rectangular with nice square flat walls, without removing too much metal.

Porting a cylinder head.



Port terminology. A - manifold face; B - port; C - guide boss; D - short side turn; E - throat; F - long side turn; G - seat; H - waterways.



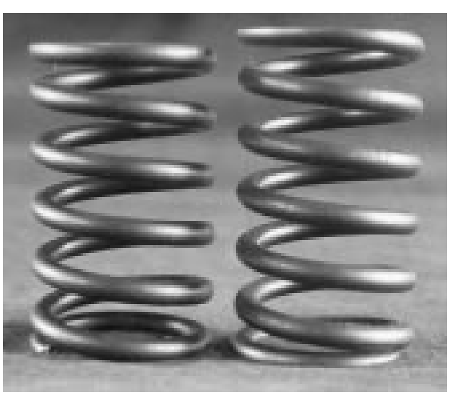
A few of the tools used during head modification work.

To get the internal dimensions similar for all the ports in the head, a pair of internal calipers is a great help. The ability to judge by feel and sight comes with experience.

To demonstrate how to modify the ports of a cylinder head, we crossmomentary separation the cam has continued to rotate, whipping round further, so when the follower lands back on the lobe it has missed a portion of the profile and its motion is no longer quite so controlled.

Valve float obviously messes up the timing of the inlet and exhaust processes during the four stroke cycle. It manifests itself as a sudden dramatic loss of power at whatever rpm it occurs, similar to a severe engine misfire. Mechanically it is not good for valve train longevity; everything crashing back together can bend or break things, like pushrods or rocker arms, not to mention damaging the cam lobe itself.

Valve float can be brought on by several factors. Over-revving the engine, tired or worn out valve springs

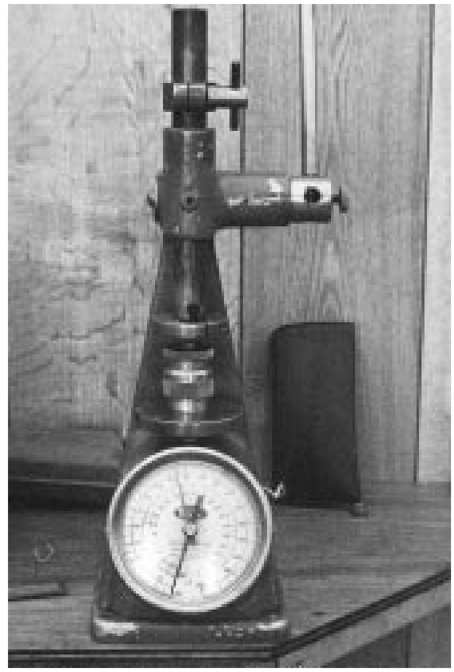


New spring (right) compared to worn (left). Note the difference in height.

(they lose their resilience over time due to heat and because of the very nature of their movement), or too aggressive a cam profile can all produce this same result. The solution is to use new or stiffer springs.

Valve bounce

Valve bounce happens when the valve hits its seat with sufficient force to bounce off again - potentially disastrous if the piston is in close proximity! It is down to the vibrations



Professional valve spring tester. In drag racing, checking spring poundage is critical.

in the entire valve train, when the engine is at high speed, acting together for an instant so that the valve arrives back at its seat much faster than intended, as it is no longer under the control of the cam or valve spring.

The cure is to stiffen up the valve train components, making them less likely to flex. Stiffer pushrods, stud girdles, stronger rocker shafts and rocker posts, etc, will help to alleviate this problem or, at least, move it to an rpm level beyond the engine's operating capability. The components should be braced or stiffened, preferably without increasing the mass of the moving parts which could lead to valve float, and you'd be back at square one.

Spring surge

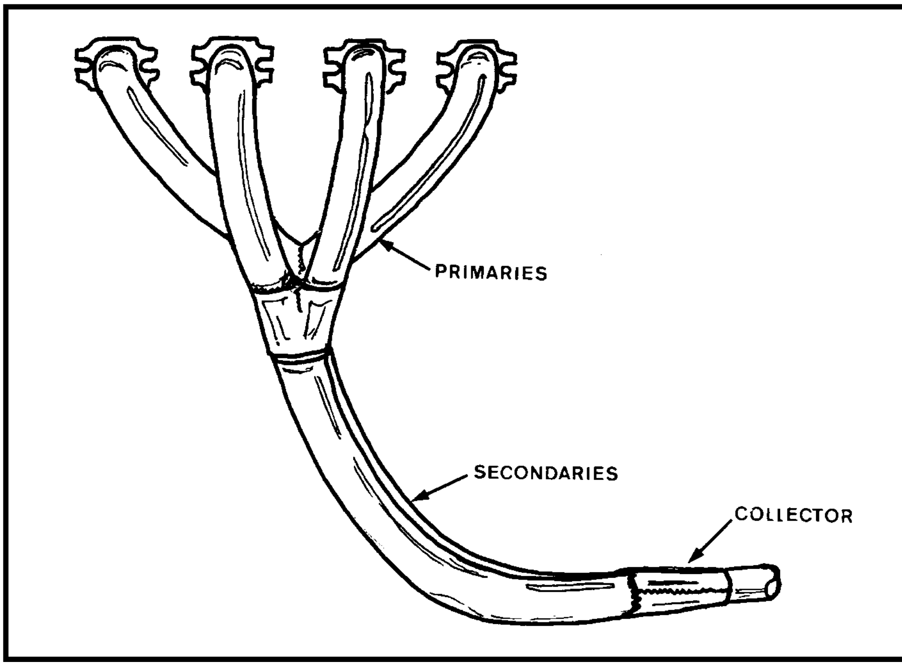
A helical valve spring has a frequency at which it will resonate (like a tuning fork), called its "natural frequency." This frequency is to some extent dependent upon the design and construction of the spring. It will also vibrate at multiples of that natural frequency.

The disturbing forces that cause spring surge are related to the design of the cam's opening flank and the speed or rpm of an engine. At a high enough rpm the frequency of the valve motion can cause the valve spring to resonate. It starts to 'do its own thing' in terms of motion, which inevitably means that the spring's effective pressure is reduced dramatically, or possibly eliminated altogether, meaning the valve train motion is no longer controlled. This may have a catastrophic effect on engine longevity.

To counteract valve float and spring surge, stiffer springs are used. To make a spring stiffer the design must be changed. The wire for the coils could be made thicker, the type of material for the wire changed or the diameter of the spring altered. This is fine up to a certain point, but problems can arise from the spring becoming coil bound at maximum valve lift, or no longer fitting physically within the constraints of the standard head, meaning machine work or a total change of valve train to accommodate.

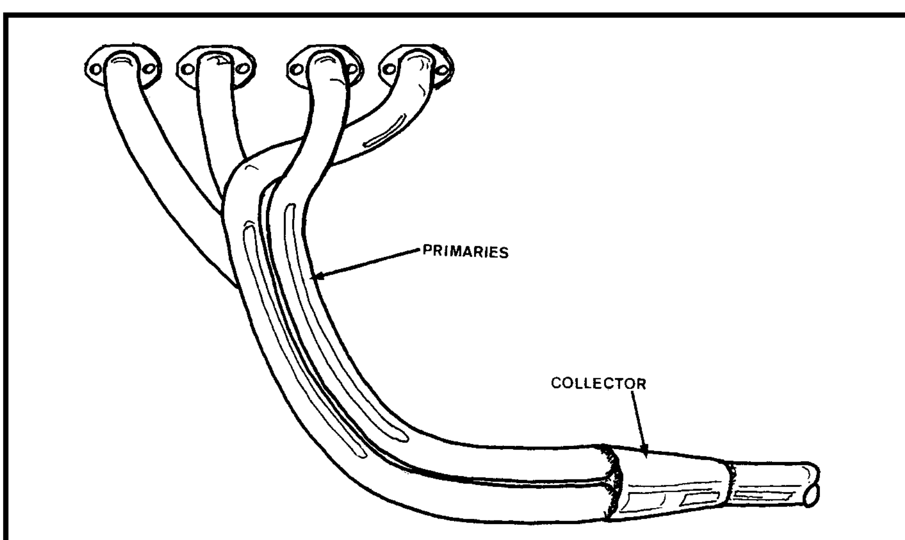
As the need for stiffer springs increases, it can outstrip the capability of a single valve spring. The next step is to use double springs and even triples in the case of high rpm race engines with radical cams. With doubles, a smaller (diameter and wire thickness) but taller spring, wound opposite to the main, is fitted inside. It is wound the opposite way to stop the two sets of coils tangling should the inner one move. The different natural frequency of the smaller spring can help cancel out any operational problems with the natural frequency of (rpm) range. On an engine equipped with a separate exhaust port per cylinder, quite a lot can be done to tailor power delivery using these principles, by playing with the exhaust manifold pipe lengths. The first pipes that make up the manifold are called the "primary pipes" which, ideally, are all the same length. These can join into further individual pipe lengths called the "secondaries" which, in turn, all combine at a single collector just before reaching the exhaust system itself.

Broadly speaking there are three types of exhaust manifold layout. The first uses very long primaries to keep each cylinder's exhaust pulses separate. This pipe length is called the "tuned length" and varies with engine design. The intention is to generate a low pressure signal in each pipe, which arrives back at the exhaust port just as the valve opens for the next exhaust stroke. All the individual pipes come together at a collector, no secondaries are used. This "independent" manifold design promotes mid to high rpm power, and is most commonly used for racing (called a "four into one manifold" on most four cylinder engines with separate exhaust ports for each cylinder).



Four into two into one manifold.

The second type of manifold has much shorter length primary pipes which are paired together - usually cylinders one and four and cylinders two and three - into two secondary pipes (which can be of similar length to the primaries) that finally come together at the collector. The entire manifold length is usually similar to that of the long primary "independent" version. In theory, the exhaust pulse from number one cylinder is helped along by the low pressure area in its primary, generated by the earlier exhaust cycle of number four cylinder, and vice versa. The same effect applies between cylinders two and three. This design is known as an "interference" manifold (or "four into two into one," or "tri-Y" design), and the effect is to enhance low to mid-range power. This design is ideal for a roadgoing engine.



Four into one manifold.

The third type of manifold evolved from the motorcycle world and is intended to combine the best of both worlds. The primaries are very long, as per the independent manifold, but then connect to a pair of secondary pipes - again similar in

FORD 2-LITRE SOHC 'PINTO'

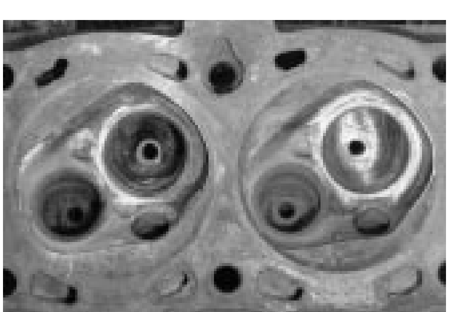
The standard head responds very well to simple or full modification work. In standard form the injection head is nearly as good as a non-injection head with the simple modifications outlined below.

Simple modifications: Cut 3-angle seats and open out the throats to match, smoothing the seats into the throat, especially on the short side of the inlet port. Modify the valves with a cut at 30° from the seat to the valve back, to break the sharp edge. Typical bhp improvement on an otherwise standard (Sierra type exhaust manifold) engine is 18%.

Full modification: To get the best results the head needs large inlet valves, 44.5mm (1.75in). The guide bosses must be ground down flush with the port. The natural angle produced from blending in the increased valve seat diameter down to the guide boss works very well with cleaned up standard shape chambers. Expect a 25% + increase in bhp.

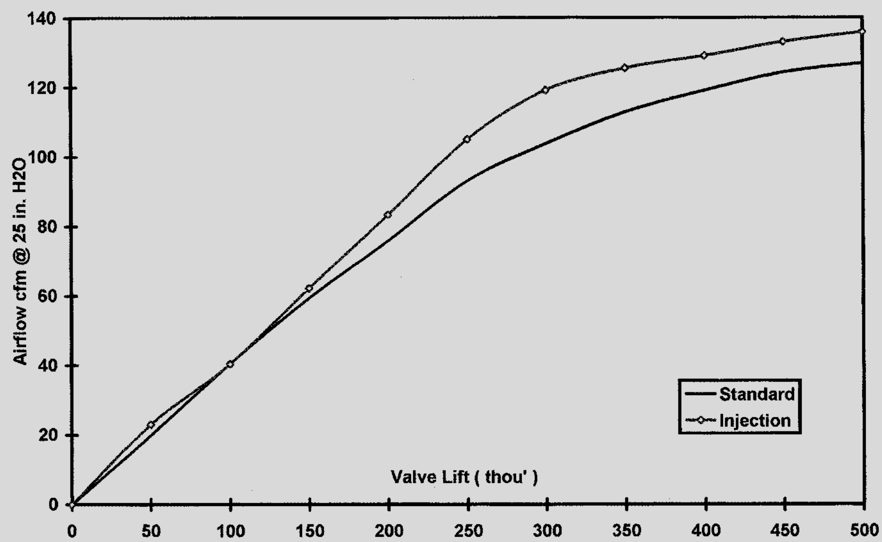
Inlet seats/throat: Stage 1: 2mm (80 thou') 30° top cut, 1.5mm (60 thou') 45° seat, 2mm (80 thou') 60° bottom cut blended into throat.

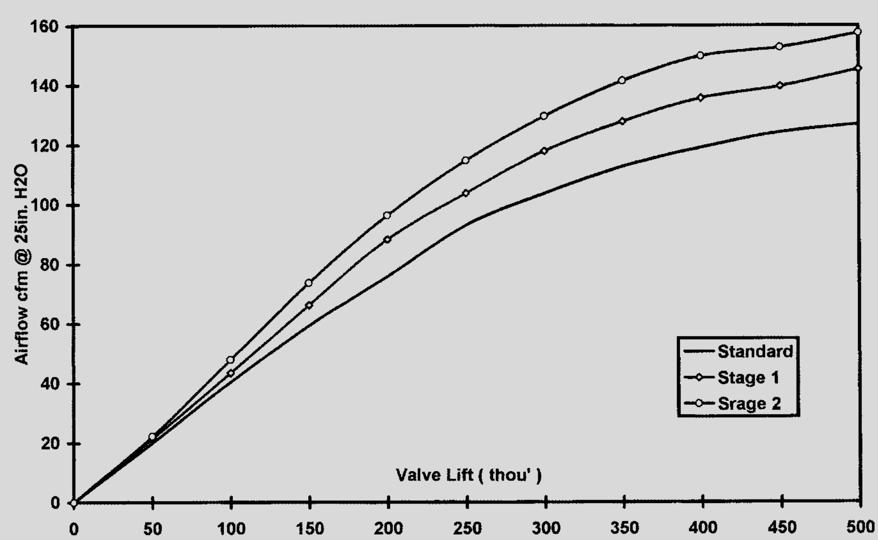
Stage 2: 1mm (40 thou') 30° top cut, 1.3mm (52 thou') 45° seat, 1.5mm (60 thou') 60° bottom cut blended into throat.



Standard and modified throats and chambers.

Lift (thou')	Std	Injection	Stage 1	Stage 2
50	19.9	23.0	21.4	22.2
100	40.5	40.4	43.5	48.0
150	59.4	62.2	66.3	73.7
200	75.9	83.3	88.4	96.4
250	93.1	105.1	103.9	114.8
300	103.8	119.2	118.0	129.6
350	112.9	125.6	127.9	141.6
400	119.1	129.1	135.7	149.9
450	124.3	133.1	139.7	154.4
500	127.0	135.2	145.4	157.5





Inlet port flow @ 25in H_2O. ('Pinto'.)