Crankshaft Balance
Practical considerations.

Tom Walker

The piece by Tim Ramsay was an erudite description of why certain things occur that we all accept as a ‘fact of life’, up with which we just have to put (to mis-quote Winston Churchill).

Now, to be honest, no matter how we might make light of it and protest the sewing-machine smoothness of our particular engine - it vibrates - and Tim explains why.

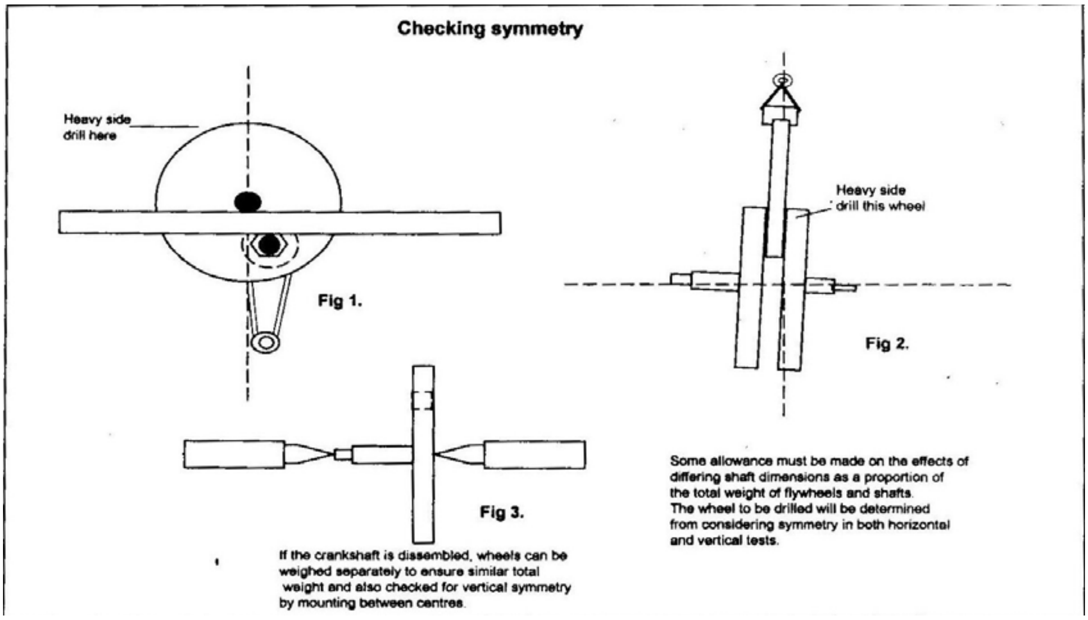
In the simplest terms, whilst there are some bits going round and round quite smoothly, there are other bits going up and down, accelerating from zero to maximum and back to zero again twice in every revolution of the crankshaft. In addition to which, in accordance with the work of Messrs Boyle and Charles, it is generating a pressure in the cylinder of many Atmospheres every second revolution (for our AMC four-stroke singles), at very high temperatures.

As Tim has illustrated, the effects of these reciprocating masses varies with their magnitude, the distance they move, the stroke (which influences their linear velocity) and the rotary velocity (revs).

As he pointed out, because of these variables, there is no such thing as a reciprocating engine that is perfectly balanced over a wide rev. range. Furthermore, the setup that suits one engine or one speed, need not hold good for other circumstances. Balance factor is a moveable feast, but for most British road-going machines is between 60 and 65%, I know a successful tuner of 74 x 81mm singles for racing who always balances to 70%, but his engines can be a bit ’rough’ below 4000Rpm!

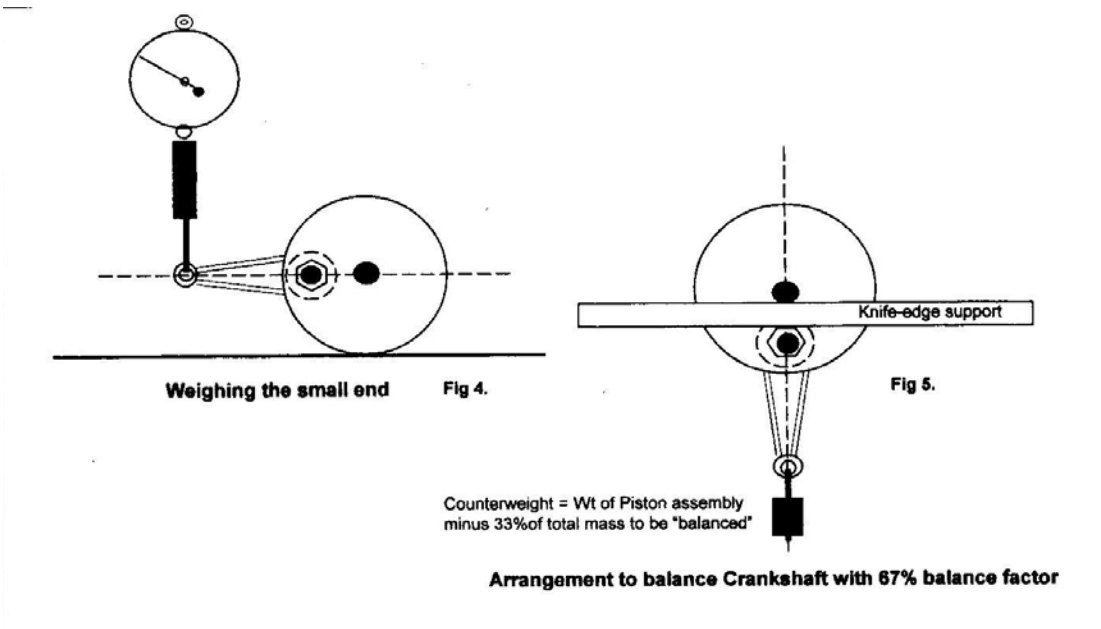
Chris Read wrote a piece for the Jampot in February 1997 in which he, quite rightly. Extolled the virtues of ‘dynamic’ balancing using sophisticated equipment similar in action to the used for wheel balancing. There is no doubt of the precision of that method and, for a twin’s crank there are particular benefits over ‘static’ balancing because of the length of the shaft and the axial distances between the various out-of-balance elements; but the principles are the same for manual methods and, with care, it has been demonstrated for many years that a quite satisfactory result can be achieved for a 4-stroke ‘single’.

In the engine, (ignoring odds and sods like cams, rockers and pushrods) the bits that have to be accounted for as reciprocating weight (for the physics purists, I am using that term loosely) comprise the piston assembly, and the upper part of the con-rod (the big-end being taken as rotating weight). The balance factor is the proportion of that reciprocating weight that is to be ‘balanced’. Hence for a balance factor of 60% the assembled crank would remain ’out of balance’ by 40% of the piston assembly and the upper con-rod. In this ’out-of-balance’ state, the assembled crank and con-rod should hang with the big-end aligned vertically with the crankshaft when it is supported on horizontal ‘knife edges’ or between centres (see figures 1-3).



The addition of a weight equivalent to that 40% to the ‘heavy’ side of the flywheels (opposite to the crankpin),or the removal of 40% from the con-rod side, should produce a ‘balanced’
crank that can be set in any position with no tendency to rotate (see below).

Determining the weight to be balanced is a simple process with an accurate spring-balance or scales. The piston assembly is simply weighed, off the con-rod, and the upper con-rod weighed with the crank on the bench with shaft and con-rod horizontal and the small end of the con-rod supported by the scales (ie. the reaction at the free end), see Figure 4.



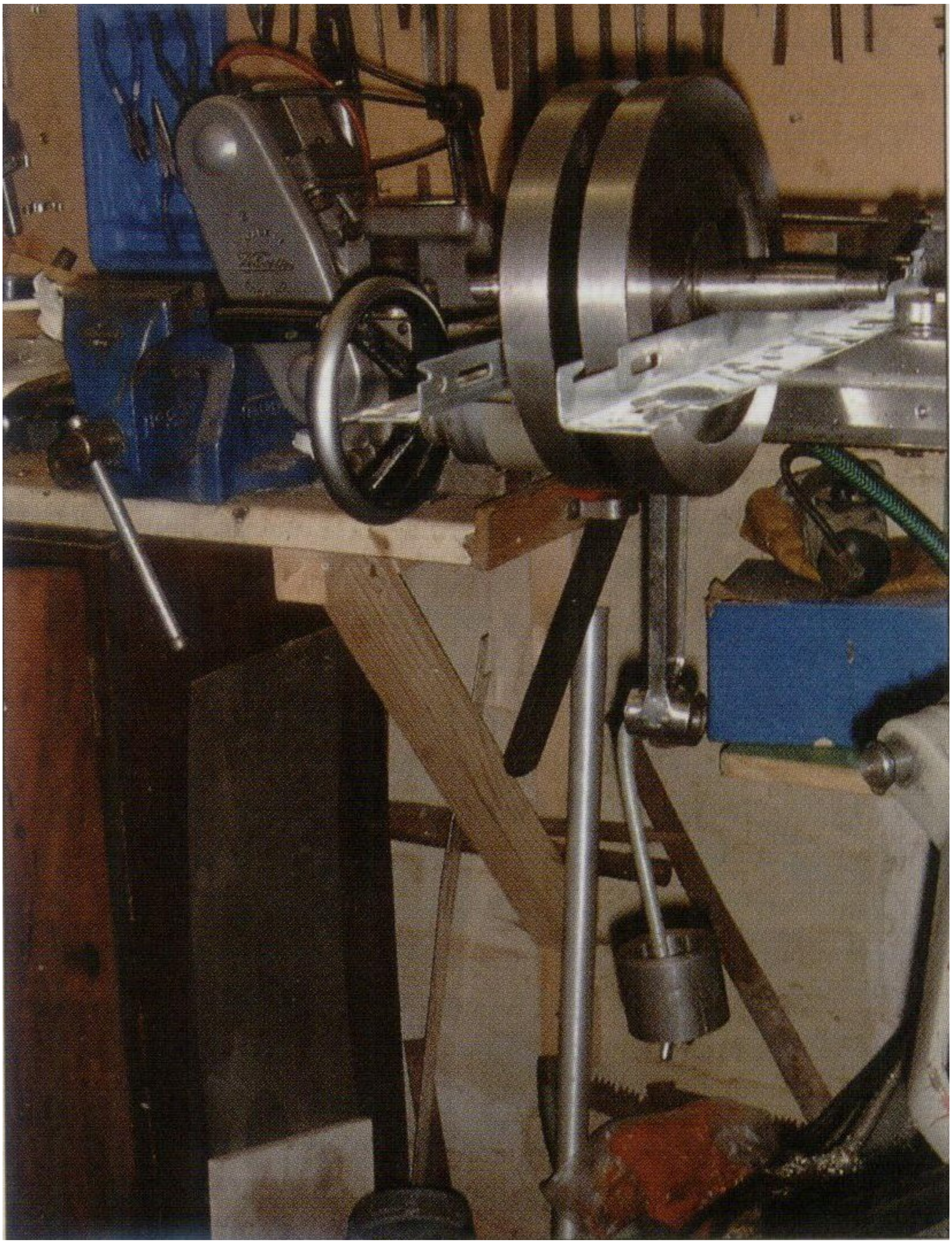
The crankshaft must then be supported on a pair of horizontal ‘knife-edges’ with an appropriate weight attached to give the requisite balance factor. E.g. If the piston assembly weighs 430 grams and the small-end 170 grams; for a balance factor of 67% the ‘out-of-balance weight’ would be 33% x 600grams, =200 grams.

Rather than attaching additional weight of 200 grams to the ‘bob weight side of the complete crankshaft assembly to achieve balance it is simpler to remove the piston assembly and attach a weight to the small-end equal to the weight of the piston minus the out-of-balance weight - in this case 430-200 = 230 grams (See Figure 5).

It then a case of checking that the crank will have no tendency to rotate, no matter in which position it is placed. If this is not the case, metal can be removed by drilling holes on the ‘heavy’ side until balance is achieved. Care must be taken to remove metal symmetrically, either side of the centre-line through the mainshaft axis and the crankpin, and evenly from each flywheel. An indication of where? And how much? Can be obtained by sticking bits of bolt of the drill-size to the ‘light’ side until symmetry is achieved, then drilling at the opposite location.

As Tim Ramsay pointed out, the chassis can have a bearing on the balance factor required for a particular application and Phil Irvine wrote of cutting holes in the crankcase of an engine, through which screwed plugs in the flywheels could be accessed for the purpose of adjusting the balance factor in testing sessions until the ‘best’ results were obtained; after which the engine was stripped and the balance weight-plugs fixed permanently.

Tom Walker.



I can’t imagine there are many readers who will feel an overwhelming urge to rush out and strip their engine to monkey about with the balance factor, but next time an engine is stripped, it might be interesting to check whether the crank hangs ‘straight’, or even to check the balance factor, just for curiosity.

Tom Walker.