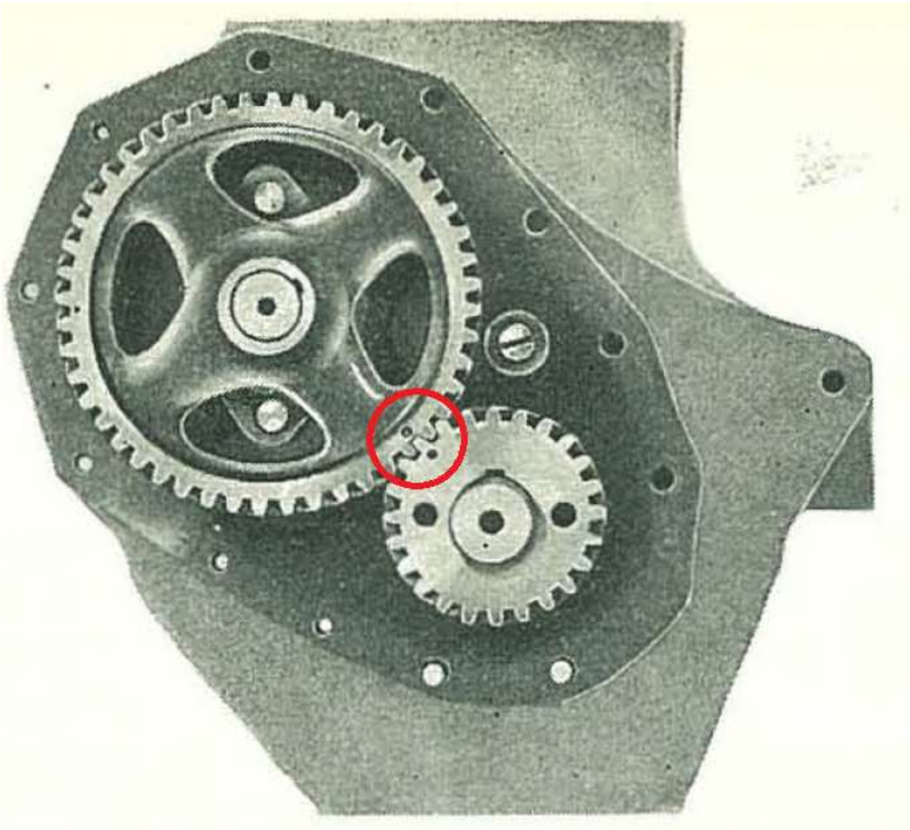
HOLDEN GREY MOTOR CAMSHAFT TIMING – Dialling in a cam

The timing of inlet and exhaust valve opening relative to piston position is determined by the camshaft. Camshaft timing should not be confused with ignition timing, which is the timing of spark firing relative to piston position. The camshaft on a grey motor is normally put into the engine in the position intended by the cam grinder (referred to as “straight up”). This involves locking the timing gear to the camshaft (and the crank gear to the crankshaft) using woodruff keys, and then inserting the camshaft into the engine so that the dots on the timing and crank gears line up (sometimes referred to as “dot to dot”, as per the image below). With everything joined together correctly, the valves open and close at the correct time relative to where the pistons are.



An alternative to running the camshaft straight up is to run it advanced or retarded. Advancing the camshaft opens and closes the valves earlier. This gives a better idle and good low-RPM power, but less power at high RPM. Retarding the camshaft opens the valves later. This gives better high RPM breathing but a poorer idle and reduced power at low RPM. Because the grey motor has a single camshaft, both the inlet and exhaust valves get advanced (or retarded) at the same time. Duration does not change, nor does overlap. For late model cars with twin camshafts (separate inlet and exhaust cams) it is possible to advance or retard the inlet and exhaust valves differently. This can have a marked effect on overlap, though duration remains constant.

Some even more modern cars (for example the Ford Barra engine) can vary cam timing on the run. This may be done for power (usually by changing the inlet cam timing) or for emissions (usually by changing the exhaust cam timing). We tend to think of variable cam timing as a modern concept (VTEC yo!), though the first use of it was in 1903 Cadillacs. For our humble grey motor, the camshaft timing can be changed, but not on the run.

Is there benefit in advancing or retarding the camshaft in a grey motor? It is very hard to predict and depends heavily on both the specific engine and what it is used for. As an example, a landspeed car could benefit from retarding the camshaft (as the engine is run at maximum RPM during a run), whereas a circuit racer might not (as circuit racers repeatedly run through both high and low RPM ranges). The only way to be certain of the benefit is to make the change and then use the car as intended, looking for decreases in elapsed times or higher speeds.

Another reason to advance or retard the camshaft timing is to ensure that the camshaft is in the position intended by the cam grinder. There are a number of reasons why the camshaft may not be in the correct position relative to the pistons:

- the cam has been ground (or reground) incorrectly,
- the timing gear, crank gear, camshaft or crankshaft woodruff key grooves have been cut incorrectly,
- the timing gear or crankshaft gear dots are not stamped in the correct location,
- the timing gear outer toothed ring has moved relative to the inner hub.
- the backlash between the timing and crank gears (either from manufacturing or wear) is excessive (should be 0.003-0.004" for a grey motor).

By advancing or retarding the camshaft the error caused by the above can be corrected. This process is referred to as "dialling in" a camshaft.

When would it make sense to dial-in a grey motor camshaft? For most applications, the answer is "never", and camshaft should simply be installed straight-up. For pooting around town and the odd highway run, any error in the camshaft timing is not likely to be noticeable. It takes a fair amount of effort to dial-in a camshaft, and with that effort comes risk. Yes, you have corrected the settings back to what the camshaft grinder intended, say by advancing the timing 2° using woodruff keys. But what if the way you use your car (perhaps mostly stop/start driving) is different to what the camshaft grinder was thinking (stop/start + highway)? Perhaps moving the timing has hurt the performance you value most. You won't know, unless you move the timing back and see if there is an appreciable difference. That's a lot of work for what is likely to be a small benefit.

If you were a dial-your-own racer, then it would make sense to dial-in the grey motor camshaft. Dial-your-own racing is a form of drag racing that involves nominating how fast your car can go, and then running as close to that time as possible (but no faster). It is the most common form of drag racing, together with bracket racing. Bracket racing is similar in that a nominated time is set (say 10.0 seconds), but everyone in that bracket must run to the 10.0 second time (instead of nominating their own dial-in time). Both dial-your-own and bracket racing are all about being consistent, but not about outright power. The most consistent car wins the race, not the most powerful. By dialling-in the camshaft, you can be confident that your engine runs exactly the same every race, every rebuild. You can then run exactly as per your dial-in time, every time. In practice though there are very few people who are dial-your-own racers running grey motors – perhaps a few running the HA/GR HAMBstr class, but not many others.

Another reason to dial-in a camshaft would be if the racing class you are operating in has restrictions on engine components. If you cannot upgrade by buying fancier parts, then you must squeeze every last drop out of what is allowed. By changing cam timing, you may get better performance out of the existing kit. An example of this would be Group N historic racing, which is popular with the humpy crowd. Whilst the camshaft can be changed, Group

N cars must the car’s make, model and year original type and design of cylinder block. In this case, it may make sense to play with cam timing to see if circuit lap times improve.

To dial-in a grey motor, the crank and cam shafts are aligned straight up. A degree wheel is attached to the snout of the crank. The motor is rotated until it is at top dead centre on number one cylinder. This can be done either by using a piston stop or by using a dial indicator. Once the engine is at top dead centre the degree wheel is adjusted so that it indicates top dead centre. A cam lifter is then inserted into the engine, and a dial gauge used to measure lifter movement. The engine is again rotated, and different measurements are checked against the cam grinders specifications noted on the cam card. The measurement used for the checking process varies. For example:

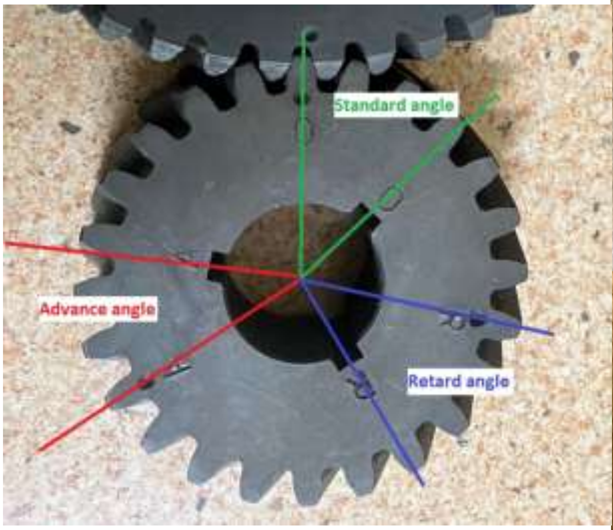
- GMH check cam timing by checking that exhaust valve lift at a marked point on the flywheel is 0.052” (no degree wheel is used), as per the image to the right.
- Clive Cams and Crow Cams recommend rotating the engine until it is at top dead centre and then checking the inlet valve lobe lift (in inches) against the cam card.
- Lunati recommends rotating the engine until the inlet valve lobe is at 0.050” and then checking the crank angle (from the degree wheel) against the cam card.
- Crower recommends rotating the engine until the inlet valve lobe is at its peak and then checking the crank angle (from the degree wheel) against the cam card.

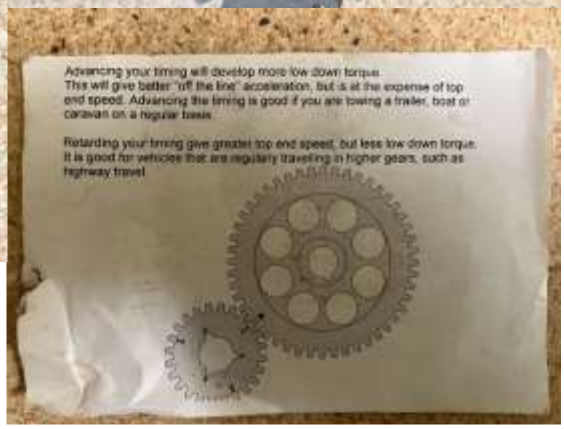
I won’t go into any more detail here, as the process for checking camshaft timing is identical to many common motors (for example small block Chev) and there are plenty of YouTube tutorials to show how it is done.

So if the camshaft is checked and found to be not aligned correctly, how is the issue corrected on a grey motor? It is possible not to align the camshaft and crankshaft gears dot-to-dot. The crank gear has 24 teeth, so moving the gears around one tooth makes a change of (360/24 =) 15°. That is a large amount to be adjusting cam timing (we are looking for around 1-4°), to is really not a practical way to correct or adjust camshaft timing.

In the past, Master Engineering made the GS138 adjustable timing set for the grey motor. These sets consist of an iron timing gear and a steel crank gear.

The crank gear has three slots, allowing the crankshaft woodruff key to be inserted straight up, 2° advanced or 2° retarded. The crank gear also has three dots (marked 0, A and R) which are then lined up to the cam gear dot when using the respective straight up, advanced or retarded slots. The gear advancement (or retardation) is achieved because the angle between the slot and the dot for each of the zero, advanced and retarded cases is different.





Unfortunately, the Master Engineering timing sets are no longer available. It is possible though to change cam timing via stepped woodruff keys (sometimes called an offset woodruff key). Both the grey motor cam and crank gears are retained with ¾"x3/16" woodruff keys (ANSI #606). Stepped woodruff keys are available in this size from Mr Gasket – part number 984G for 0°, 987G for 2°, and 988G for 4°. The image to the right shows a standard woodruff key (top), the 987G key (middle) and the 988G key (bottom).

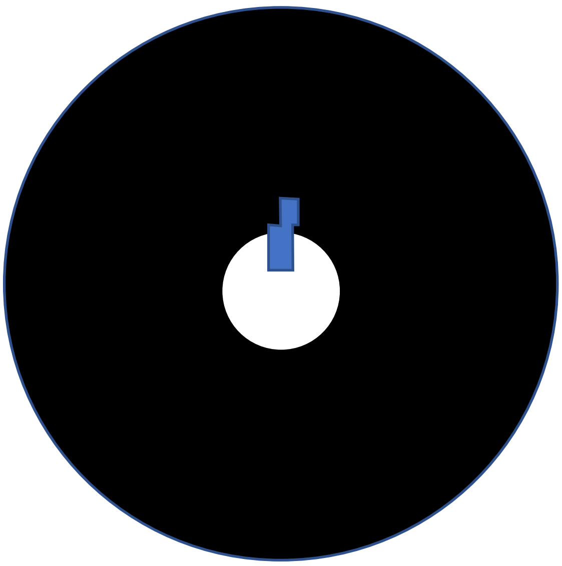
ENGINE COMPONENTS

MR. GASKET

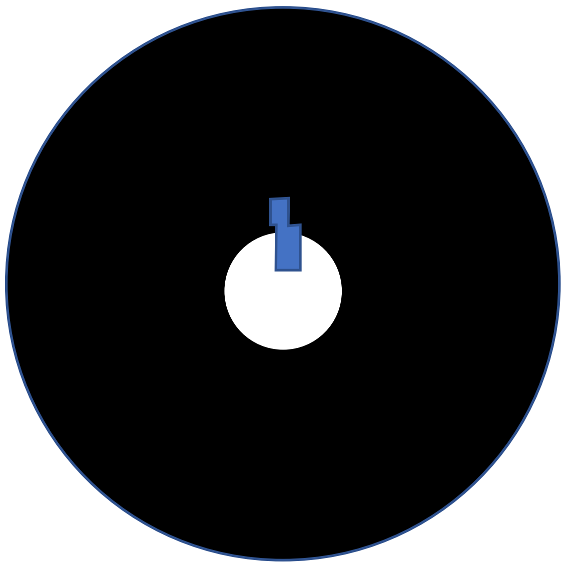
CRANKSHAFT AND CAM KEYS*

STOCK REPLACEMENT CRANKSHAFT KEYS			
APPLICATIONS			**PART NO.**
CHEVROLET	Small Block 283-400	Long Style	983G
		Short Style	984G
	Big Block 396-427-454	Long Style	983G
CHRYSLER	273-318-383-426, Hemi	Long Style	983G
OFFSET CRANKSHAFT KEYS			
CHEVROLET	283-400, (Long Style 1-3/8")	Silver 2°	985G
	Small & Big Block (Short Style 3/4")	Silver 2°	987G
		Copper 4°	988G
CHRYSLER	273-318-383-426, Hemi	Silver 2°	985G
OFFSET CAM KEYS			
PONTIAC	389-400	Silver 2°	987G
		Copper 4°	988G
CHRYSLER	354-392	Silver 2°	987G
		Copper 4°	988G
6 CYL. FACTORY GEAR DRIVE			
CHEVROLET	In-line 6	Silver 2°	987G
		Copper 4°	988G
FORD	In-line 6	Silver 2°	987G
		Copper 4°	988G

So what happens when you install one of these keys? Before we get carried away, bear in mind that the keys can be inserted into the keyways in one of two positions. In one position the tang sticking out of the shaft rotates around clockwise to the one o'clock position. Turning the woodruff key the other way around makes the tang stick out at the eleven o'clock position. The diagram below shows the two positions.



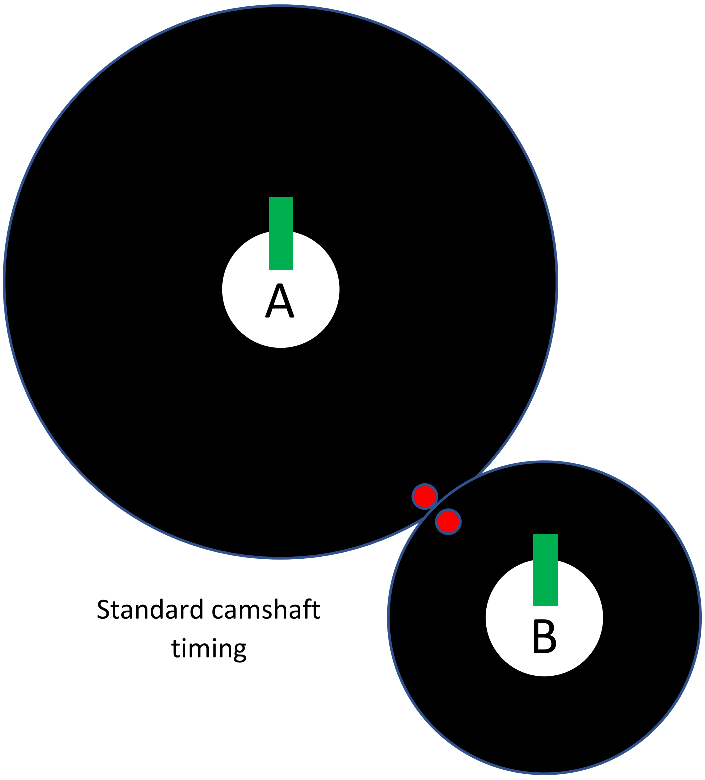
The "one o'clock" position



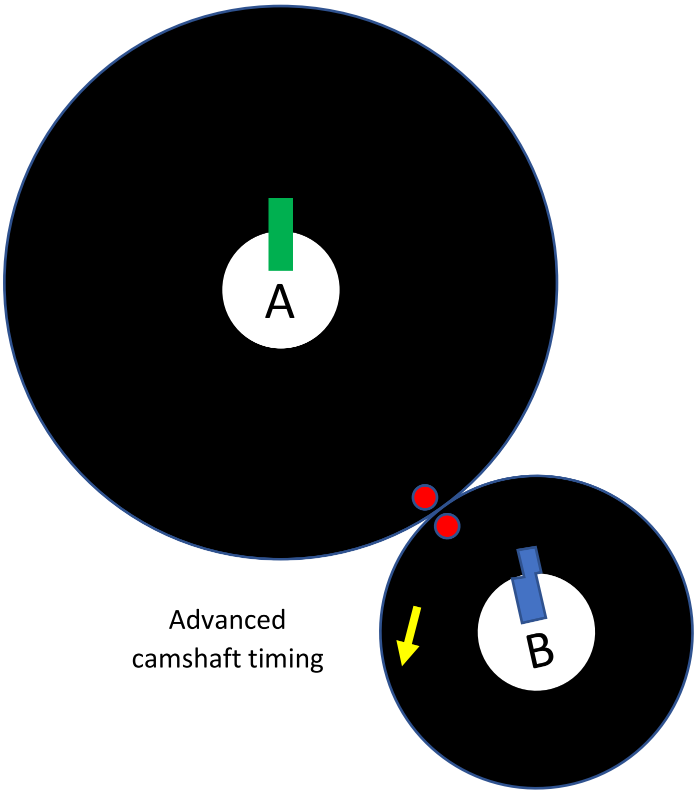
The "eleven o'clock" position

The difference between the one o'clock and eleven o'clock positions is that the woodruff key makes the gear rotate in different directions relative to the shaft. The gear on the left above (one o'clock position) has been moved clockwise relative to the shaft. The gear on the right above (eleven o'clock position) has been moved anticlockwise relative to the shaft.

The picture below shows a cam gear (large black circle – labelled A) meshed with a crank gear (small black circle – labelled B). The timing dots (red) are shown aligned to each other. Each gear is held in place with a standard, zero offset woodruff key (green).

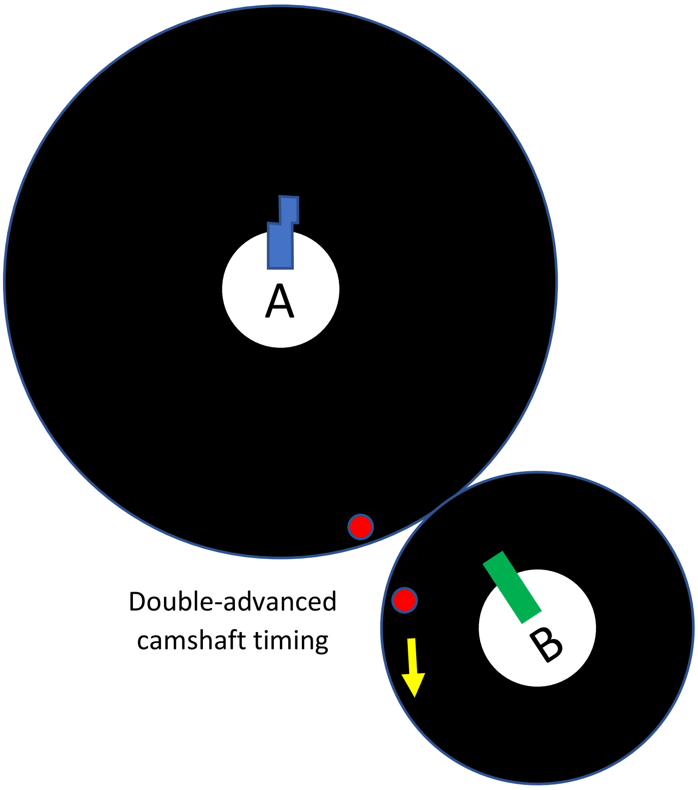


We can then replace the crank gear woodruff key with one of the Mr Gasket units. The Mr Gasket woodruff key is shown in the diagram below in blue. Note that I am showing the Mr Gasket woodruff key in the one o'clock position. The effect of doing this is to advance the camshaft – the diagram below has the timing gear A in the same position, but the crank gear B is now rotated in the direction of the yellow arrow (i.e. crank is earlier in the cycle, or advanced timing). If the Mr Gasket woodruff key had been placed in the eleven o'clock position it would have retarded the camshaft.



Advanced camshaft timing

The alternative is to place the Mr Gasket woodruff key into the cam gear. This is shown in the diagram below in blue. Again, the diagram is showing the Mr Gasket woodruff key in the one o'clock position. The effect on the timing is the same (the crank gear again moves in the direction of the yellow arrow, advancing the camshaft timing).



Double-advanced camshaft timing

However, the difference here is that the Mr Gasket woodruff key has turned the cam gear instead of the crank gear. Due to the differences in gear sizes, this means that camshaft has been advanced twice as much as it would have been if the Mr Gasket woodruff key was used in the crank gear.

If we got even more clever, we could use an offset woodruff key in both the cam and crank gears. With two different locations (cam and crank), three different key types (zero offset, 2° and 4°) and two alignment options (one o'clock and eleven o'clock positions) there are twentyfive different combinations of timing change (though some of these amount to the same effect – see table below). Of note, whilst it is cool to be able to adjust the camshaft timing by 12°, that much change is not likely to be useful. Typical camshaft timing corrections/changes are 0-4 degrees.

In short:

- The Mr Gasket woodruff keys advance the camshaft timing when used in the one o'clock position and retard the camshaft timing when used in the eleven o'clock position.
- If used in the crank gear, they advance the timing by a set amount.
- That set amount can be doubled if they are used instead in the camshaft gear.
- By using the keys in various locations, the following changes in timing can be made:

Crank	Camshaft	Effect (crankshaft degrees)
988G key in eleven o'clock position	988G key in eleven o'clock position	-12°
987G key in eleven o'clock position	988G key in eleven o'clock position	-10°
988G key in eleven o'clock position	987G key in eleven o'clock position	-8°
Standard key	988G key in eleven o'clock position	
987G key in one o'clock position	988G key in eleven o'clock position	-6°
987G key in eleven o'clock position	987G key in eleven o'clock position	
988G key in one o'clock position	988G key in eleven o'clock position	-4°
988G key in eleven o'clock position	Standard key	
Standard key	987G key in eleven o'clock position	
987G key in one o'clock position	987G key in eleven o'clock position	-2°
987G key in eleven o'clock position	Standard key	
Standard key	Standard key	0° (straight up)
988G key in eleven o'clock position	987G key in one o'clock position	
988G key in one o'clock position	987G key in eleven o'clock position	
987G key in one o'clock position	Standard key	+2°

987G key in eleven o’clock position	987G key in one o’clock position	
988G key in one o’clock position	Standard key	+4°
Standard key	987G key in one o’clock position	
988G key in eleven o’clock position	988G key in one o’clock position	
987G key in one o’clock position	987G key in one o’clock position	+6°
987G key in eleven o’clock position	988G key in one o’clock position	
988G key in one o’clock position	987G key in one o’clock position	+8°
Standard key	988G key in one o’clock position	
987G key in one o’clock position	988G key in one o’clock position	+10°
988G key in one o’clock position	988G key in one o’clock position	+12°