Starting Off the Switch - What It Is and How To Do It.

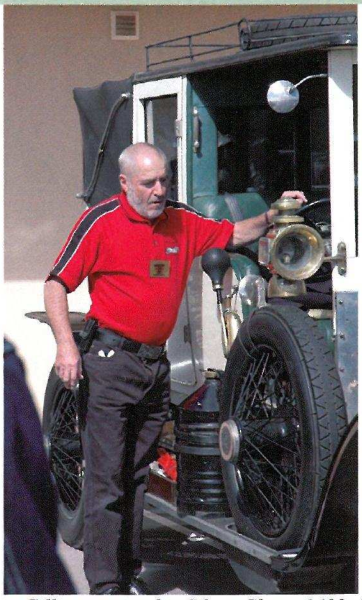
Barrie Gillings (NSW) © 2006

Requirements: a 20hp, 20/25hp, 25/30hp, Silver Ghost, Phantom I or Phantom II in good running order with correctly adjusted carburettor and ignition, and whose engine turns freely. A new, tight engine may not do it! But a nicely run-in engine usually will, and a tired, worn-out engine probably will.

'Starting off the switch' describes starting an engine without the use of the crank handle or the starter motor, and was a highly prized feature of early motor cars. Before starter motors were developed (in 1912), you started your car by turning on the ignition and hand-cranking. If your car had a big engine and an inefficient magneto, this could be quite difficult and many owners left their car on a hill and roll-started. The introduction of the battery-powered 'trembler box' improved matters by producing very large sparks and easier starting but was not as reliable as a magneto and many cars used both systems, trembler for starting and magneto for running. But cranking with either or both ignition systems could be very dangerous if it was attempted with the ignition control in the advanced (early) position. In this case the engine can run backwards, engage the crank handle and break the cranker's wrist or arm. There was even a descriptive term this injury: 'Chauffeur's fracture'. NEVER HAND-CRANK YOUR CAR WITH THE IGNITION ADVANCED.

To understand 'starting off the switch', it helps if you have some knowledge of how an internal combustion engine works. It is a 'heat engine', which produces power by burning an ignitable fuel. The heat produced expands gasses in a cylinder, which push against a piston. The piston then turns a crank. All the R-Rs mentioned above have six cylinders, so we will limit discussion to them. They have a crankshaft with six offset cranks, a crankhandle facility at the front and a flywheel at the back. Attached to the cranks are connecting rods joining the pistons to the cranks. The pistons move up and down in the cylinders. The cylinders are fed by a fuel/air mixture produced by the carburettor. The cranks are arranged at 120° intervals along the crankshaft to ensure a smooth delivery of power. Viewed end-on, the cranks look something like the Mercedes-Benz three-cornered star (see Figure 1).

Our cars operate on the 'Otto', or four stroke cycle (see Figure 2). The first stroke is 'intake', where the piston starts at 'Top Dead Centre'(TDC), when its crank points straight up. As the piston goes down, it sucks in the fuel/air mixture ('the charge') past the now open inlet valve. The second stroke, 'compression', starts at the bottom of the inlet stroke. The inlet valve closes and the now rising piston compresses the charge. You can feel this 'compression' when you



Barrie Gillings, using his Silver Ghost, 1492, in his practical demonstration of 'Starting off the Switch' as part of the 48th Western Gold Federal Rally, Orange, 6 April, 2006. Photograph - Editor.

crank your car. The third stroke starts as the piston again passes TDC. The sparking plug fires, the charge burns, expands the compressed gasses and they force the piston down in the 'power' stroke. At the bottom of the power stroke, the exhaust valve opens; the piston rises and expels the hot, burnt charge in the 'exhaust' stroke. Then the cycle repeats.

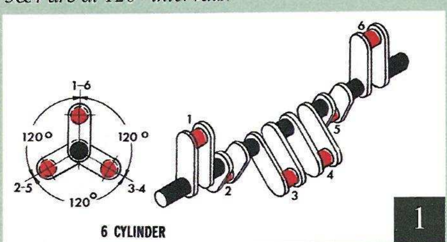
Now we need some knowledge of fuel mixtures and ignition timing. Petrol can burn at a fuel/air ratio, by weight, in the range: 1 part fuel for 7½ parts air (rich or strong) to 1 part fuel for 20 parts of air (weak or lean). Outside these limits, the mixture will not burn. Our cars run well in the mixture range of 1:14 to 1:16, roughly what you get moving the mixture lever from STRONG to WEAK.

Ignition timing is more complicated. When the charge in the cylinder is compressed, then ignited by the sparking plug, a 'flame front' of burning mixture spreads out from the spark. This is not instantaneous. It takes time. If the ignition occurs at TDC in a fast-running engine, the charge is still burning and expanding the gas when the piston is almost at the bottom of its travel, so some of the expanding gas energy is wasted in the exhaust. To ensure that the expanding gas and resulting pressure increase transfer energy efficiently, the charge should be ignited in advance of TDC, by an amount proportional to engine speed. Then the maximum pressure in the cylinder occurs around the middle of the power stroke. Thus for efficient fast running, the ignition should be 'advanced', or 'early', and the faster the engine is running, the more advance it can take. But to start the engine, and especially hand-crank the engine, it is wise to have the ignition retarded, so that when the spark occurs, the piston is past TDC and there is, then, no way the engine can run backwards and break your arm. Most R-R battery ignitions are set to 'spark' 5-10° after TDC to avoid this possibility. But the magneto is usually set in advance of TDC, so if you must crank on magneto, be sure to do it vigorously, so that the flywheel will carry the piston past the compression of TDC before the fired charge starts to expand. See Figure 3.

Now for starting 'off the switch'. When you switch off your engine, it will continue to rotate and continue to suck in a fuel/air mixture. But because the mixture is not ignited, (because there is no sparking), engine rotation slows down and eventually stops. This is because the flywheel energy is lost through compressing the charge, turning the water pump and the sliding friction of bearings and pistons. But the compressing of the charge by the rising piston is (more or less) balanced by the expansion of the compressed (but not burning) charge against the piston, which is on its power stroke. So if you watch the fan blades of your well run-in engine, you will see that after switching off, the blades continue rotating anti-clockwise, then slow down, and, finally, oscillate alternately, clockwise then anti-clockwise, as the compression stroke and firing stroke try to balance each other out. Then, finally, friction stops the movement. This oscillation is represented by the diagram in Figure 4.

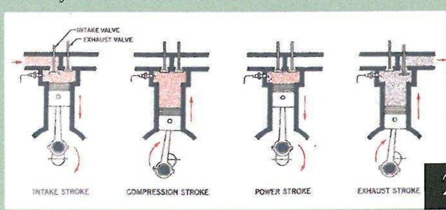
While the above is taking place, the pistons have been sucking in and exhausting unburnt fuel/air mixture. So, when the switched-off engine stops, one piston will be on its compression stroke and one piston on its firing stroke, and each will contain an ignitable charge of fuel/air mixture. So will the exhaust system, and this occasionally goes bang! But that is another story. You might think that the charges in the compression and power stroke cylinders are in a compressed form. (Folk may say, but erroneously: "It holds its compression well"!) Pressure is held initially, but not for long. Piston rings do not provide a perfect seal, because the rings have gaps to allow for expansion, and valves can leak a little. Thus a compressed charge only stays compressed for a few seconds, then leaks away. The mixture in the compression and power stroke cylinders then reaches atmospheric pressure. If the compression ratio of the engine is, say, 4 or 5 (i.e. 4-5 times atmospheric pressure), each charge will be about a quarter of its usual strength, but will still have a lot of potential energy. A full charge can exert about two tonnes on a piston, so even a 25% charge still has quite a kick.

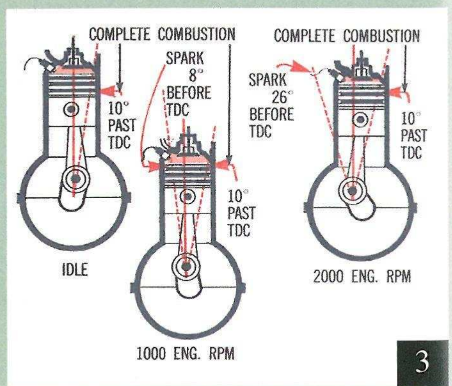
Below [1]: The cranks are arranged around the crankshaft, and the pistons fire in the order 1,4,2,6,3,5. Viewed end-on, the cranks 1&6, 2&5, 3&4 are at 120° intervals.



Below [2]: The 'Otto' cycle, viewed from the front of the engine. Note that the full cycle involves TWO REVOLUTIONS of the crankshaft.

Right [3]: At idle, the fuel air mixture is best ignited up to 10° after TDC. At 1000 rpm, the ignition is best advanced about 10° before TDC. At 2000 rpm, 20° or more of advance can be used.





We are now ready to 'start off the switch'. The 'power stroke' cylinder will be about 60° past TDC and the 'compression stroke' cylinder about 60° before TDC, the positions depending on how freely-rotating the engine is, how well the valves seal and so on. You can visualise the positions by thinking of the Mercedes-Benz star with one arm pointing down. If we now spark the sparking plug in the 'power stroke' cylinder, it will ignite the charge, and there is usually enough hot gas expansion to push the piston down past bottom dead centre. If this happens, the next piston will go past TDC, and its charge will then fire. We have now fired two 'undercharged' cylinders, but all the following cylinders will be fully charged, will fire in turn and your engine will now be running normally.

So, to start you car 'off the switch', you will need a few revs up so that the engine 'runs on' after you switch off. It will also help if the mixture is rich rather than lean and your engine rotates freely, so that the firing cylinder is past, but not way past, TDC. The charge in the power stroke cylinder piston will quickly leak down to atmospheric pressure but still allow you to start 'off the switch' for an hour or so. Some owners have claimed 24 hours or more. Eventually the charge in the cylinder is diluted by exchange with the atmosphere, so to 'start off the switch' after several hours, your pistons and valves have to seal well.

So how do we cause a spark in the relevant sparking plug? There are two ways. The first way is to own a Silver Ghost which is pre-WWI. These models have a battery ignition system that uses a 'trembler coil'. This is, in effect, a conventional coil, switched on and off very rapidly by a buzzer, or trembler. The distributor and its rotor then provide six volleys of sparks per distributor cam revolution. The cam is hexagon-shaped, with six pointy bits, 60° apart, separated by six flat bits. For roughly 30° of rotation, the breaker arm in the distributor sits on the flatter bits, and the points in the distributor are in contact (closed). For the next 30°, the points move out of contact (open) because the pointy bits move the breaker arm out. In 1906 to1915 Silver Ghosts, the spark volley which fires the piston occurs when the distributor points close, or MAKE contact and supply electricity to the buzzer. You can tell when this occurs because the trembler makes a buzzing noise.

When the engine is running, each sparking plug fires when the distributor points first contact. But in early Ghosts, contact is maintained, the trembler keeps buzzing and the sparking plug keeps firing for about 30° rotation after contact. This doesn't matter, because the sparking plug has already fired the charge in the cylinder. But what happens if the battery ignition is turned on after the engine has stopped and the power stroke piston is 60° past TDC and its cylinder holds an ignitable charge?

For 30° of distributor rotation, there are sparks but this is 60° for the engine because it rotates twice as fast as the distributor. Thus it is highly likely that when the ignition is turned on, the trembler will still tremble even though the engine is 60° past TDC. Now we come to the clever bit. The distributor rotors for R-Rs, which can start 'off the switch', differ from ordinary rotors. A distributor rotor carries sparks from its centre to a conductor on its edge, then to the contact connecting with the appropriate sparking plug. The edge conductor must be long enough to allow the spark to be advanced and retarded appropriately. In our cars, the edge conductor is especially long, from 35° to 50°, and can supply a spark to a piston 60° or more past TDC. See Figure 5.

So, in an early Ghost, with the ignition lever set to LATE, turning on the trembler is likely to send a volley of sparks to the descending piston's sparking plug, even though it is 60° (+/-) past TDC. The charge fires, then the next one fires, and so on, and the engine starts. But it is important to note that, if the spark lever is set to 'early' (advanced), the sparks that occur at switch-on are intended for the next, ascending, 'compression stroke' piston. Now the engine will probably run backwards, producing dramatic white smoke, and it will take perhaps 6-10 hand cranks to recharge the cylinders for re-starting. The effect is the same if you hand-crank your engine with the ignition advanced, so don't attempt it.

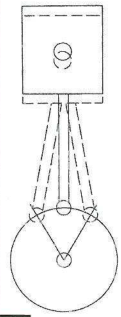
Now we consider the second way of starting 'off the switch'. With ALL R-Rs from 1919 to 1934, ignition is by conventional coil (and perhaps magneto as well). Here the spark is produced, not when contact is MADE in the distributor, but when it is BROKEN. This is an entirely new ball game. To start 'off the switch', we need to BREAK a circuit. In early Silver Ghosts, the MAKE is easy. You do it by simply turning on the trembler ignition and the car starts, as described above. With all later R-Rs you must first turn on the ignition. Then you BREAK the distributor points contact, which then produces a single spark as the coil's magnetic field (aided by the condenser) collapses.

When you switched the engine off, your ignition control lever was probably in the early (advanced) position. If you now turn the ignition on, the coil is energised and ready to discharge when the rising 'compression stroke' piston reaches its firing position (from 10° to 30° or more before top dead centre, depending on the R-R model you have). Until this occurs, the distributor breaker arm is on the flat bit of the hexagon-shaped distributor cam. Furthermore, the ammeter will show a few amps discharge, indicating that the coil is energised.

But you can move the ignition lever from 'early (advanced) to 'late' (retarded). When you do this, you rotate the distributor breaker arm backwards on the distributor cam, and off the flat bit. The points open on the backward, instead of the usual forward slope, and a spark is produced by the coil. And because the distributor rotor has a very long contact area, (see above), this spark is delivered to the sparking plug of the 'power stroke' piston, even though the latter may be up to 60° PAST TDC. The reduced charge then fires and the engine starts, as described above. If it does not start, you can repeat the advance/retard motion over and over, and sometimes the repeated sparking heats the recalcitrant charge sufficiently to fire it and start the engine. If your car has dual ignition, you might as well have both ignitions on, as the magneto does not interfere with this process, and may even help by providing an additional spark after the first charge fires. See Figure 6.

A final caution: If you leave your pre-1919 Silver Ghost in gear and have not disconnected the battery, a passer-by can easily rotate the ignition knob and the car may leap away and cause a mischief. If you leave your 1919-1935 RR in gear, someone in the driver's seat may turn on the ignition and retard the spark, with the same result. Don't leave your car in gear, or if you do, open the master switch. Alternatively, keep meddlesome bystanders at arm's length.

Right [4]: If you watch the fan blades or the flywheel of a freely rotating engine after switching off, you will see an oscillation, represented here by the dotted lines, just before the engine stops. Now the compression stroke piston and the firing stroke piston will be approximately 60° before and after TDC.



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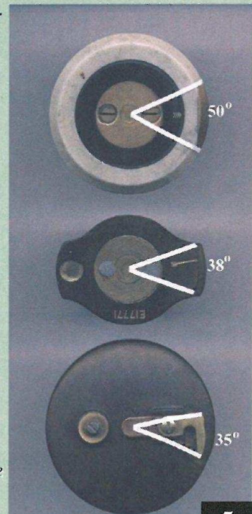
Right [5]: Distributor rotors for: top, a pre-Armistice Silver Ghost; middle, a Vintage Ghost; bottom, 20hp, 20/25hp, 25/30hp, PI and PII. The white lines show the angles through which the edge contact of the rotors can feed a spark to a sparking plug. The angles are more than enough to accommodate the possible range of rotor positions (where the engine stops) and distributor positions (early to late).



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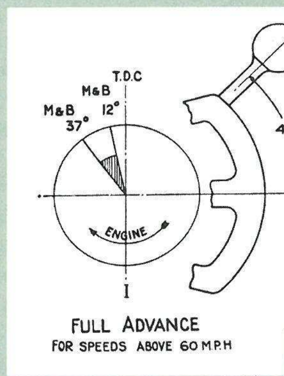

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Above and below [6]: This shows the position of spark occurrence for a Phantom II, with the ignition lever in full advance (top) and full retard (bottom) positions, but IN RELATION TO TDC ONLY. The angles do not apply for cylinders 60° before or after TDC. The 90° advance-to-retard movement of the ignition lever, represented here, produces a 30° to 40° backward rotation of the distributor, which then opens the points, makes the spark, and starts the engine "off the switch" as it says in the handbook.

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