



Electronic Ignition

Fred Winterburn

The ignition system used on our vintage Morgans is the famed Kettering battery ignition system which replaced Magnetos on Cadillac cars in about 1908. The Kettering system had an amazing 70 or more years as the standard ignition on most cars. Magnetos were generally reliable and self powered by the engine's rotation, which is probably why they are still used in light aircraft. The advantage of being self powered was countered somewhat when engine speed was low, making spark energy weaker and starting more difficult, especially in cold weather. Some magnetos produced very high spark energies, but spark energy alone is not a reliable measure of a good ignition system. Ford had its own self powered system used on the Model T that also suffered low spark energy at low engine speeds. These self powered systems also used magnets that would become weaker over time resulting in even less spark energy, but that usually took many years to become a problem. The Kettering system was an improvement in a couple of ways. Spark energy was dependent on battery voltage and less dependent on engine speed. The other advantage was cost. The Kettering system was inexpensive to manufacture. However, it did require that the car have a storage battery on board, but that requirement led to the fitting of electric headlamps replacing the acetylene lamps in use previously. Having a storage battery also opened up the possibility of the electric self starter, another of Kettering's great achievements.

As engine speeds and compression were increased, the requirements of the ignition system increased beyond what the Kettering system was capable of giving. Dual point systems increased dwell times, thus increasing high rpm potential. 12V systems (standard post war on most British cars) came into being which improved the ignition a little, but not as much as one would assume. This is because breaker point erosion increases by more than double the rate if they are required to break more than 4 amps, so the increase in voltage really only meant better starting because of a faster turning starter motor. With the Kettering system, slow opening points do not make a clean break and coil output will be very low with a slow turning starter motor; low enough in fact that there may be no spark at all. If the breaker points are made larger to compensate for a higher current coil, they won't burn as easily but will be more prone to bouncing due to the increased mass. If the breaker point spring is made stiffer to counteract the bounce, the rubbing block will wear very quickly, affecting the dwell and the timing. Points bounce is a big issue with the Kettering system especially on high revving engines or V8s that have twice the spark rate of a 4

cylinder for a given rpm. This meant that at cruising speeds, a V8 engine was misfiring constantly, but went unnoticed by the driver. The answer was electronic ignition, of which there are several types.

Most people assume that electronic ignition means getting rid of the breaker points. That is what Pertronix does amongst others, but that is only one kind of electronic ignition. The first electronic ignitions were known as 'Transistor Switch' ignitions and retained the points. The points merely triggered a power transistor that handled the heavy current. This made the points last almost indefinitely providing the rubbing block and cam were lubricated once in a while. The initial rate of rubbing block wear proceeds roughly at the rate the points erode due to high current on the Kettering system until such time (8 to 15 thousand miles) that the points need filing or replacing. Once the rubbing block beds in, the rate of wear decreases, and with occasional lubrication the points will usually stay in adjustment for at least 30 thousand miles providing the switching current is kept low. Later variants of transistor switch ignitions had dwell extension circuitry to increase spark energy at higher revs. Magnetic and optical triggers were developed with Hall effect triggers coming later to replace the points. Ford installed a points triggered Transistor Switch ignition on some models in 1962. GM installed a breakerless Transistor Switch ignition on some 1963 Pontiac cars. There were many, many, aftermarket systems as well. The problem with Transistor Switch ignitions was that in order to increase spark energy, special coils and long dwell times were used that increased the current draw from the normal 3 or 4 amps, to 7 amps or more. This could make short work of small capacity ignition switches (eg, vintage Morgan) and did not increase the effectiveness of the ignition by much. The same is true of modern points replacement systems such as Pertronix. They do make starting a little easier and high speed potential is increased due to longer dwell from no points-bounce. These are all inductive systems as are the systems in use today by all (to my knowledge) automotive manufacturers. A modern inductive system with multiple coils is more like a Capacitor (capacitive) discharge ignition than the inductive system used by Kettering or the Transistor Switch systems of yore.

That leads into the next kind of electronic ignition which is called Capacitor or Capacitive Discharge ignition. Used on almost every motorcycle and small engine built today, they were not in widespread use on automobiles primarily because of the increased cost of the separate power supply circuitry which is unnecessary on most small engines, but needed with an automobile en-

gine. Oddly, it was the automobile that first benefited from the CD ignition despite the extra complication in that application. The other factor was reliability. A poorly designed CD ignition could be as unreliable as a poorly designed Transistor Switch inductive system of the era. A good CD ignition was also much more expensive to produce than a Transistor switch type inductive ignition. GM used a CD of their own design in one variant of the Delcotronic ignition system of the late sixties. One was triggered by points and another was magnetically triggered. Both were complicated, unreliable, and

The most successful solid-state CD design was also the first to be built commercially starting in early 1963 and was based on my late father's (F. Lloyd Winterburn) final patented design dating from 1962. It was the first functional and reliable solid-state CD ignition utilizing an SCR (Silicon Controlled Rectifier, also called thyristor—which is a solid-state switch that when triggered offers a low resistance path for the capacitor to discharge through the primary of the ignition coil). The first SCRs were trigger-happy devices and spurious triggering of the SCR had been a problem with previous



mediocre performers. GM abandoned the concept and went to a high energy inductive system with great success. However, some cars would only function well with a CD ignition. Porsches and early Wankel engine cars required a CD ignition for reliable operation. A combination of a fast rising voltage spike to fire through fouled or wet spark plugs, with much higher peak currents was necessary in those fuel hungry engines. The early NSU Wankel of 1964 used a Bosch thyatron CD ignition that worked well despite having to warm up, that is, until the thyatron (tube type predecessor of the Silicon controlled Rectifier or Thyristor) failed from age and vibration in the harsh environment of an automobile.

designs unlike the old thyatron which was easier to control. Dad had been running CD ignitions using thyatrons on and off since 1952 as had many others, but had an SCR model of his own design in 1961 on his 58 Beetle which used the points as a trigger. His brother James, had a 1960 Jag XK150 that had a troublesome ignition, so Dad made another CD unit for his car. It did not work very well on the Jaguar. Crossfire in the distributor due to points bounce rendered it nearly useless on the 6 cylinder Jag when it worked well on the 4 cylinder VW, and a greyish paste formed on the points insulating the contact surfaces (thought to be from ozone and oil fumes). Trigger current was increased slightly to keep the points clean without burning them, and the anti-



points bounce circuitry was developed which made it perform well on any car. This took place in April 1962. One year later it was in production by Hyland Electronics, and in use on hundreds of vehicles in the Ottawa area and elsewhere in Canada within the first months of production. Dyno testing showed major improvements on most cars, but the real improvement was fuel mileage with the minimum being a 5% improvement, and more on a V8.

It was very popular with hill climb racers in the Ottawa area. I watched a happy customer blow his Mini Cooper engine to bits in our driveway in 1964 after Dad installed a Hyland unit for him. The units were easy to install, but this fellow wanted the inventor to do it for him. With one foot casually outside the open door, and the other on the gas pedal, the fellow blipped the throttle repeatedly with the big tach swinging wildly and a big grin on his face. The noise was deafening while I watched my father coming out of the house gesturing for the guy to stop revving the engine. It was too late, and with a loud bang the noise suddenly stopped, with bits of engine and an oil slick running down the drive. Apparently the engine made it just past 12000rpm and came apart on the sudden deceleration as he lifted his foot off the gas pedal. His smile changed to a frown, but he had another engine installed and was racing by the next weekend with the CD.

One of the effects of nearly constant ignition energy at any rpm and immunity to points bouncing, was very high rpm potential. The CD was designed to augment the existing ignition components, retaining the original coil and distributor and triggered by the points, so installation was quick and easy. Coils would last longer as they no longer got hot storing energy. The coil acted as a pulse transformer instead, as the discharge capacitor dumped its energy into the coil primary in about 300 microseconds. The spark was generated in the first 15 microseconds of the capacitor discharging, hence the fast voltage and current rise of a CD ignition which allowed it to fire through condensation or carbon fouled spark plugs. The Kettering by comparison has a voltage rise about 10 times slower. By then, most of the current could have leaked away to ground with a fouled spark plug.

Only Hyland Electronics was licensed to build the Winterburn design, and the rest built it without permission. This is a long story worthy of a book in itself, so I'll be very brief. The best was the Hyland ignition built in Ottawa Ontario starting in early 1963 and built until late 1965 in which my father was chief 'engineer' and minor partner. (Dad was not an Engineer, but was RCAF trained and self taught in electronics from an early age) The next best, and most famous was the Delta Mark 10 built in Colorado starting in late 1964. There were many others that used the same basic design with

some being well built and others poorly built, with most built in the United States. In 1967, Magnetti Marelli copied the design almost exactly as per the patent, and used the system known as the Dinoplex, on V12 racing Ferraris. Bosch finally went to a solid state CD ignition in the late sixties and expedited the German patent process for my father in the early seventies. In the end, Bosch bought all of the European patents for the system. They paid less for the British Patent since Lucas owned the entire British market at that time. The Bosch CD ignition used elements of Dad's patent, but was considerably more complex and less effective. However, the honesty and generosity of the Robert Bosch company defrayed some of the losses incurred by my father. This was the only money other than a small amount from Hyland that Dad made on the ignition. Years of court battles, all in the United States, drained his resources even with a win every time. The first, and most costly, since it held up the US patent until 1971 (patent applied for in Sept 1963 and not applied for one year earlier due to the Canadian Department of National Defence deliberating on whether it had military value) was an interference suit launched by an American who claimed to have invented first. Despite no physical evidence of priority, it was not discovered until years later, that the transistors he claimed to have used in his circuit hadn't been produced prior to Sept 1963. The lawyers and my father had been concentrating on other dubious claims and missed the obvious lie that would have settled the matter years earlier! Once the US patent was granted in early 1971, more court proceedings followed, but despite wins against infringers, no royalties were paid. With no jail time or fines for breaking the law, companies reneged on royalty payments. Also, by 1975 it was becoming obvious that the design was dated as most manufacturers were converting away from points triggers to magnetic triggers, and the anti-points bounce circuitry that was a major part of the patent had become obsolete, so that's where the story ends.

Dad's design was a breakthrough in the sense that nobody else until that time had been able to make a proper CD ignition using the recently invented SCR, although many companies were trying, including Malloy and Chrysler Corp. Looking back on the design now, you would wonder that it hadn't been done sooner based on its utter simplicity.

It may come as a surprise to many, as it did me, that most CD ignitions produce less spark energy than the Kettering ignition, and considerably less than some Magneto ignitions. Manufacturers of CD ignitions tend to advertise the energy stored in the capacitor as the spark energy, which is incorrect, as only a small fraction of that energy is in the actual spark. A CD ignition can be made to produce a long duration, very high energy spark and although it's easy to do, it's not necessary, nor

practical. Erosion of the spark plugs and any other high voltage contact such as the rotor and ignition cap contacts would be swift, without any gain in performance or economy on most engines. The ignition of fuel is still not fully understood, but one thing is clear; it is high spark current delivered in a short period of time that ignites fuel the best. That is, a high spark power as opposed to more energy delivered in a longer time period.

quite different. The CD spark is blue and well defined, while the Kettering spark is orange with hundreds of secondary sparks making up the whole spark event. A CD spark sounds like a miniature flash of lightning with a really sharp 'crack' or 'snap' to it. The Kettering spark has a lower volume 'sputtering' or 'crackling' sound even though more energy has crossed the spark gap.



That's how a CD ignition can out-compete a Magneto delivering up to 5 times the spark energy, without eroding spark plugs. A longer duration spark will only be more beneficial if the spark power is maintained throughout the entire spark duration. The spark power and duration required depends on the engine and the conditions it is working under, so nothing can be simplified when it comes to ignition as there are many variables. The commonly accepted notion that a CD ignition cannot light lean mixtures, and the only way to do it is with a multiple spark CD is false. On some engines perhaps, but not all. Interestingly, the modern inductive systems found on cars today have spark durations almost as short as the longer duration, single spark event, CD ignitions.

When comparing the spark visually in a spark gap of a CD induced spark and the inductively induced spark of the Kettering system, one sees and hears something

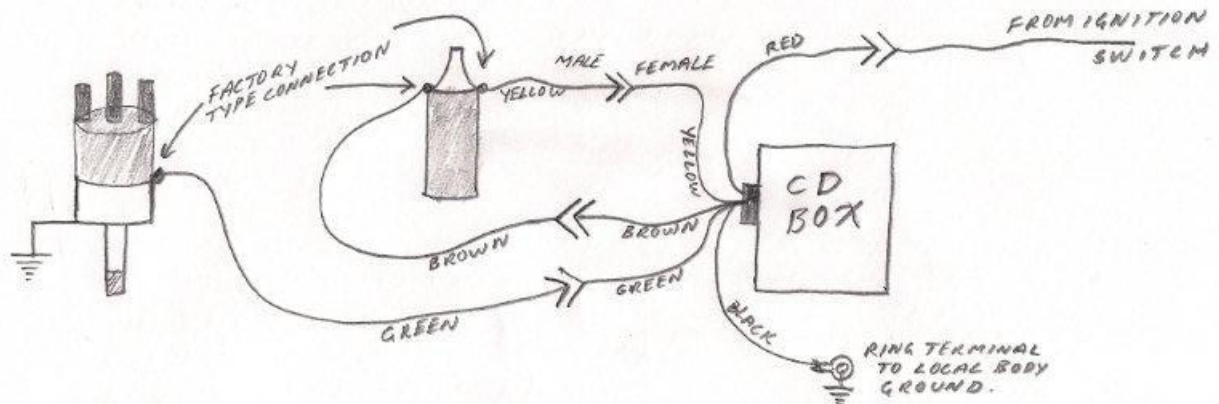
I've been running a positive ground Hyland prototype circa 1963 on my Morgan the last few years and it works like it was made yesterday. If there is fuel in the carbs, the engine will start on the first compression even with a weak battery. Fuel mileage is better and so is power. After running CD ignitions on old cars for over 35 years now, I'm a believer. Some are better than others and the ones made today which are targeted towards racing engines may not be the best option on our old cars due to the very high available voltages they produce and excessively fast voltage rise times. Also, some will not operate well below 8 volts which means they might not be helpful getting your old car started with a weak battery. However, despite that, if I did not have old units that were designed to be kind to older ignition components, I would install a modern CD ignition triggered by points in a heartbeat, and pay it off in fuel and tune-up savings.

I've built a few prototypes of a modern equivalent of the old Hyland ignition with the exception that it is more versatile. The old Hyland came in 4 models, so that the customer could buy a model that fit their specific car whether it be 12V or 6V, positive or negative ground. The ones I've built are still triggered only by the points, but are compatible with positive or negative ground cars in one unit. It has two switches. The first switch has 3 positions: STD (Kettering)-Off-CD. The second switch is active if the first switch is selected CD, and it has 2 positions: 6V-12V. The unit will operate down to 3.5 volts to get a car started easily with a weak battery. The unit has a rather large discharge capacitor charged to a lower voltage than the typical racing CD ignition, which has a rather small capacitor charged to a very high voltage. This does several things that are beneficial on an old car. It slows the rate of rise of voltage and current so that the good characteristics of a CD ignition are kept to fire fouled or wet spark plugs, but not so fast as to short to ground inside the distributor. It reduces the available voltage so that on a misfire due to a loose plug wire for example, the high voltage spike does not damage insulation anywhere in the ignition system (which is something modern automotive ignitions don't

have since they rely solely on the plug gap to control voltage) It also prolongs the spark duration with a standard iron bar coil with high leakage inductance. The size of capacitor used (in this case 2.2uF) is a compromise between spark plug erosion, unit current draw at high rpm, and the necessary voltage to fire plugs gapped sensibly in a high compression engine. The larger capacitor also makes the output voltage less variable with engine rpm which naturally regulates the power supply from the load end. This allows the power supply to be compact and energy efficient, while still allowing up to 8000rpm on an 8 cylinder or 16000rpm on a 4 cylinder car, even with the unit in series with a ballast resistor if one is equipped. Current draw is under 1/2 amp per 1000rpm on a 4 cylinder. I've included a picture of the wiring for the unit with a comparison to the Kettering system to show how simple the installation is.

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CD BOX IN SERVICE



CD BOX BYPASSED

