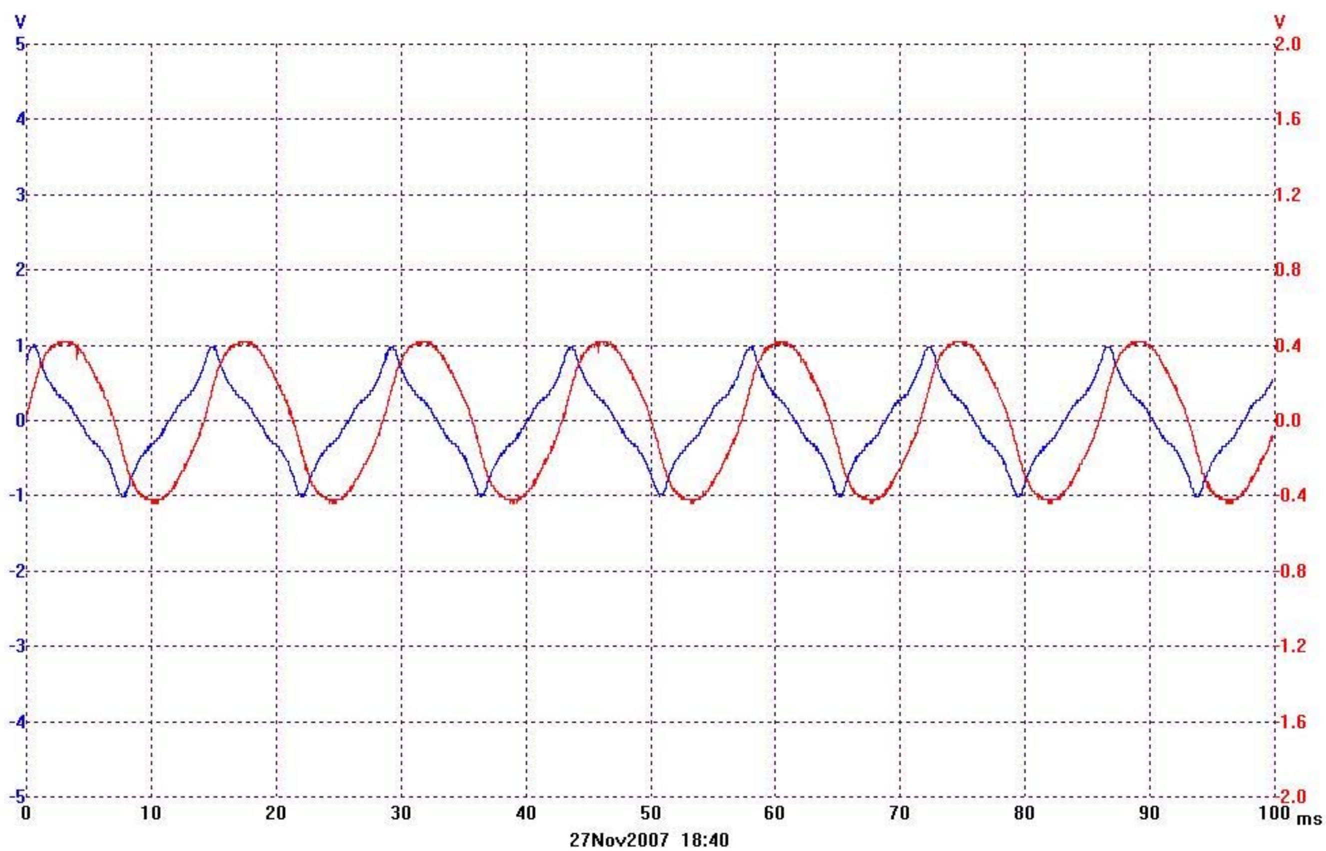
Perhaps More Than You Wanted To Know About The Model T Ford Ignition System Part 2

By Tom Carnegie

Introduction:

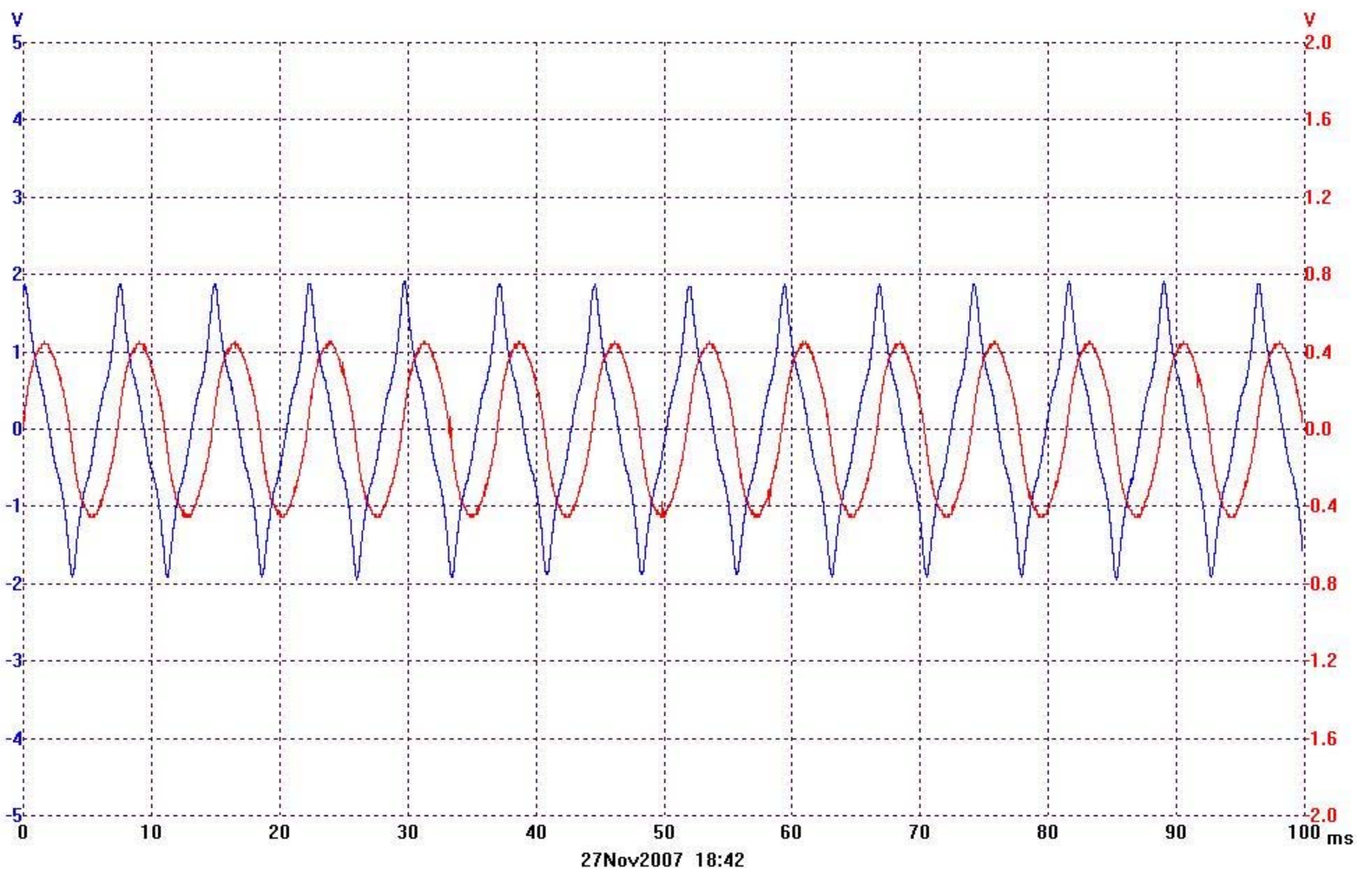
Most of my readers should be fairly familiar with the operation of the model T Ford ignition system. The purpose of this article is to give an in-depth look at the system - not to draw any conclusions necessarily, but rather to just show what is going on. I will show some oscilloscope traces of what I've observed. I will try not to be "technical", but because of the nature of the situation some "technicality" is inevitable. I will not spend a lot of time defining terms, as that would make this article much longer than I want it to be.

AC operation: The model T magneto puts out a form of alternating current. Below is a graph of a magneto powering a model T coil. The points on the coil were shorted out.



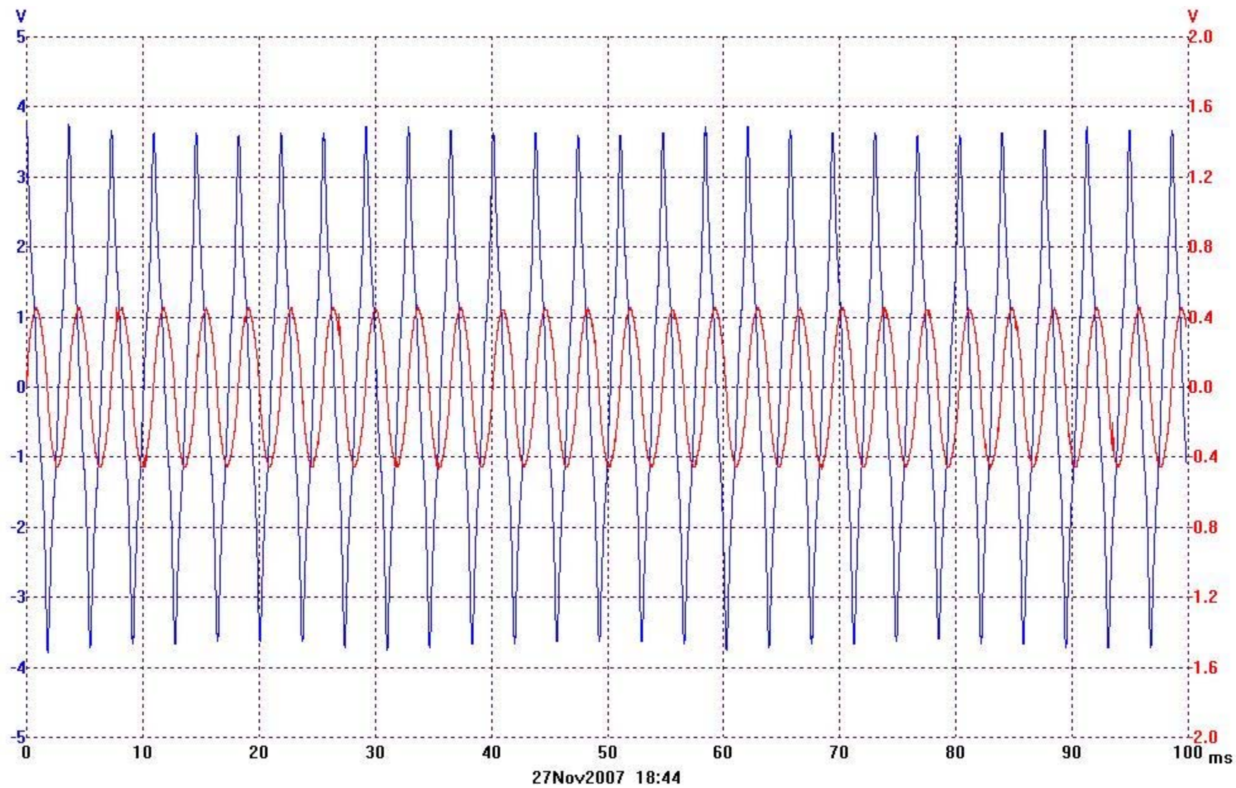
The speed of the magneto was 500 rpm. The voltage is the spiky waveform and the current is the smooth waveform. The voltage is about ten peak volts and the current is about four amps. Most ac voltmeters show rms voltage. Rms voltage is equal to the dc voltage value that would produce the same amount of heat as the ac voltage. For the model T magneto waveform the rms voltage is about 1/2 of the peak voltage.

A word about 'scope traces. These graphs are just an approximation of the actual situation. Voltage, which is also known as electromotive force (emf), tension, electrical pressure and potential, is not directly measurable. The only way to look at voltage is to sample the effects of the potential across a resistor and then measure the current. All voltmeters work in this manner. Sometimes a mechanical analogy will help a person to understand an electrical situation. Mechanical pressure gauges work in the same manner as a voltage gauge. For example, a tire gauge measures the distention of a diaphragm of known resistance. Just as it is impossible to read tire pressure without using a little bit of the pressure within, it is impossible to measure voltage without using up a bit of it. The voltage waveform on the T magneto can be skewed by a number of things. Any load on the mag skews the waveform. For example, a lightbulb, or some such resistive load will apply drag to the magnetic field created by the flywheel magnets. This torque will pull the magnetic field backwards. For example, if you are running on mag and have mag powered headlights, your ignition timing is going to be retarded by at least as much as the load of the headlights is skewing the voltage waveform.
Below is the current and voltage waveform taken through the same coil as before. This time the magneto is turning 1000 rpm.

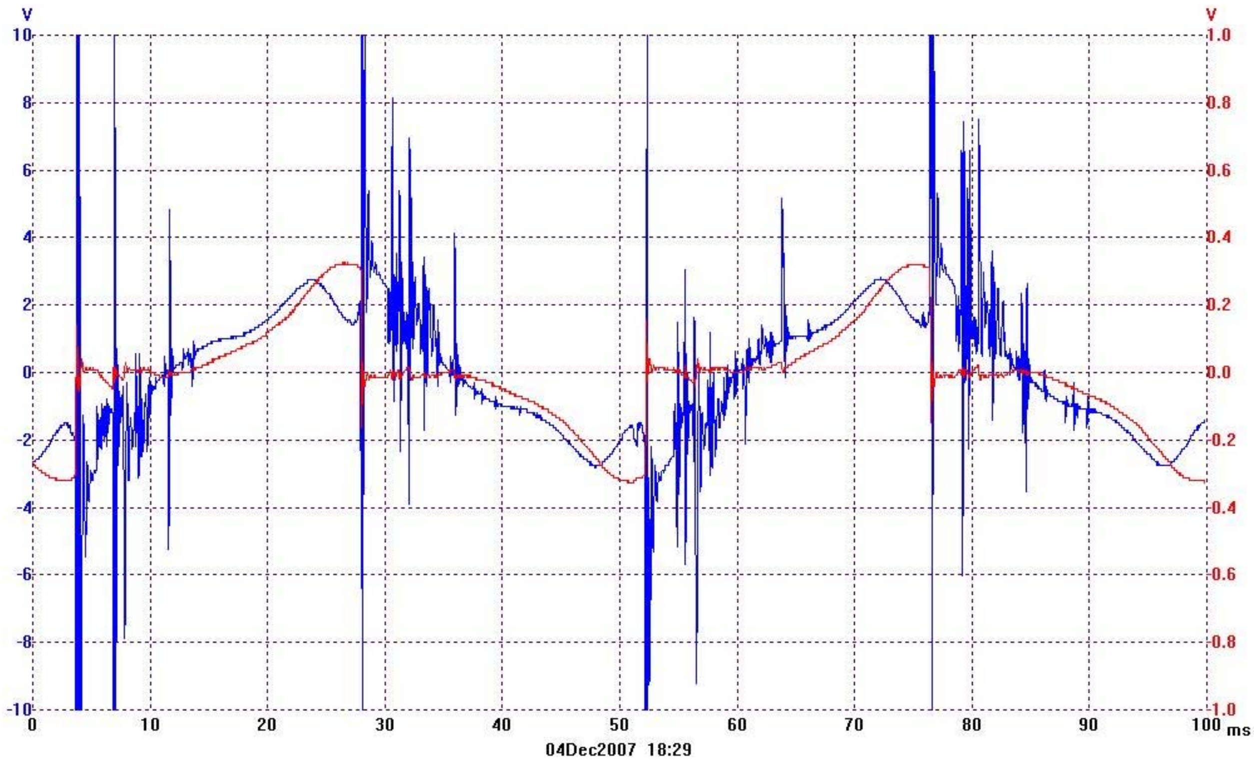


The voltage is now about 20 peak volts. The current, however is still at about four amps. The current essentially stays the same because as a load, the model T coil is mostly reactive. This means that as the magneto tries to put current into the T coil, the T coil tries to put current back into the mag. The faster the mag tries to put the current in, the more the coil resists and a sort of equilibrium is reached.

This graph shows the action at 2000 rpm.

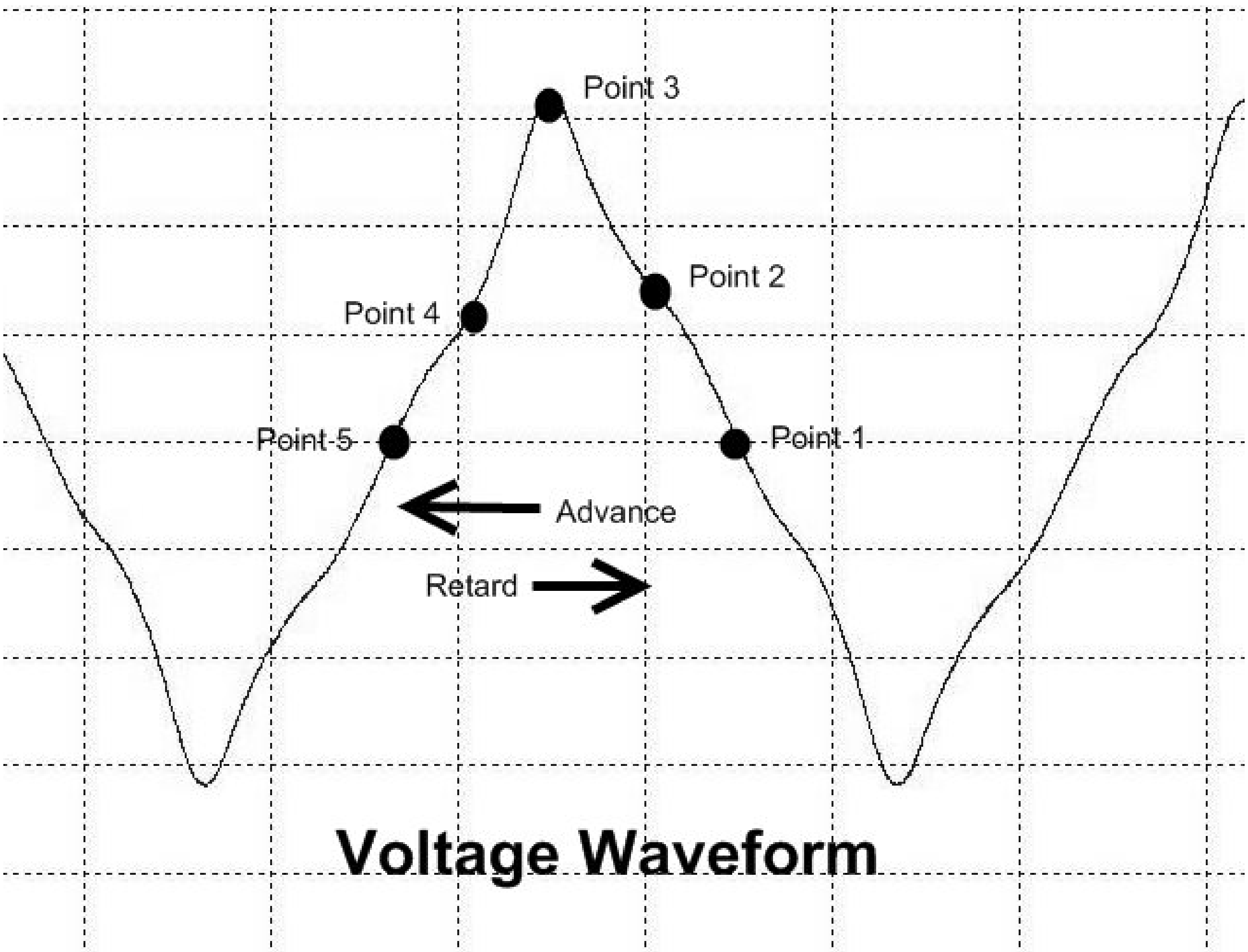


If the T coil were a perfect inductor with a perfectly reactive circuit, it would shove exactly as much current back into the mag as the mag is shoving into it. Alas, nothing is perfect. The circuit has some resistance so it loses a little there. This is called “copper loss”. The coil itself has in addition to copper loss some magnetic inefficiencies. These are mostly in the form of eddy currents and hysteresis. Eddy currents are currents imparted to the magnetic core. This current is not used and therefore wasted. Hysteresis is another word for backlash. In this case it is magnetic backlash. The alternating current magnetizes the core alternately north, then south and so on. When the field switches polarity there is a little lag because the core sort of wants to keep its polarity the way it was. The combined magnetic losses are called “iron losses”. Our main point of interest in regard to the operation of the model T coil on magneto is hysteresis. Not only magnetic hysteresis, but mechanical hysteresis. Mechanical hysteresis is mainly from two sources, the inertia of the points and the point drop on the upper point.

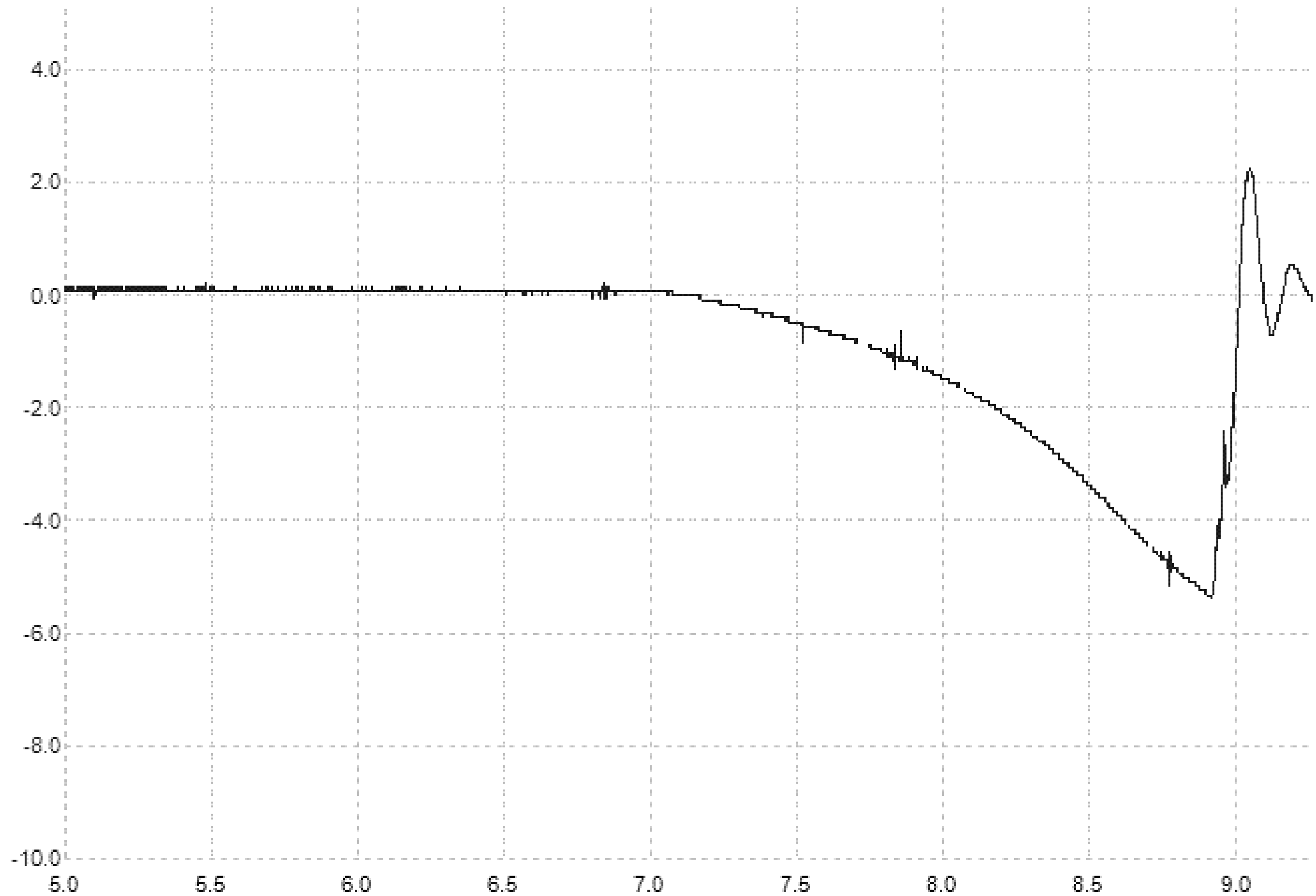


Above is a graph of a coil firing as if on a hand-cranked coil tester. The volt and amp scale are both from –10 to 10. There are 8 cycles per revolution on a T mag. There are 60 seconds in a minute and 1000 ms in a second, so if we take the time of a complete cycle (about 50ms in the above graph) and multiply its reciprocal by 60000/8 we will arrive at the rpm. The above graph was taken at about 150 rpm. At this speed it takes about 14ms for the coil to fire from the zero point on the amp waveform. One might think that the coil would fire when the coil reached peak amperage, but in fact it fires just slightly on the downward side of the amp peak. This is the result of mechanical hysteresis.

Operating a coil on a steady AC voltage is a common way to test and set up a coil. In reality, the model T coil never encounters this situation. The reason for this is the timer.

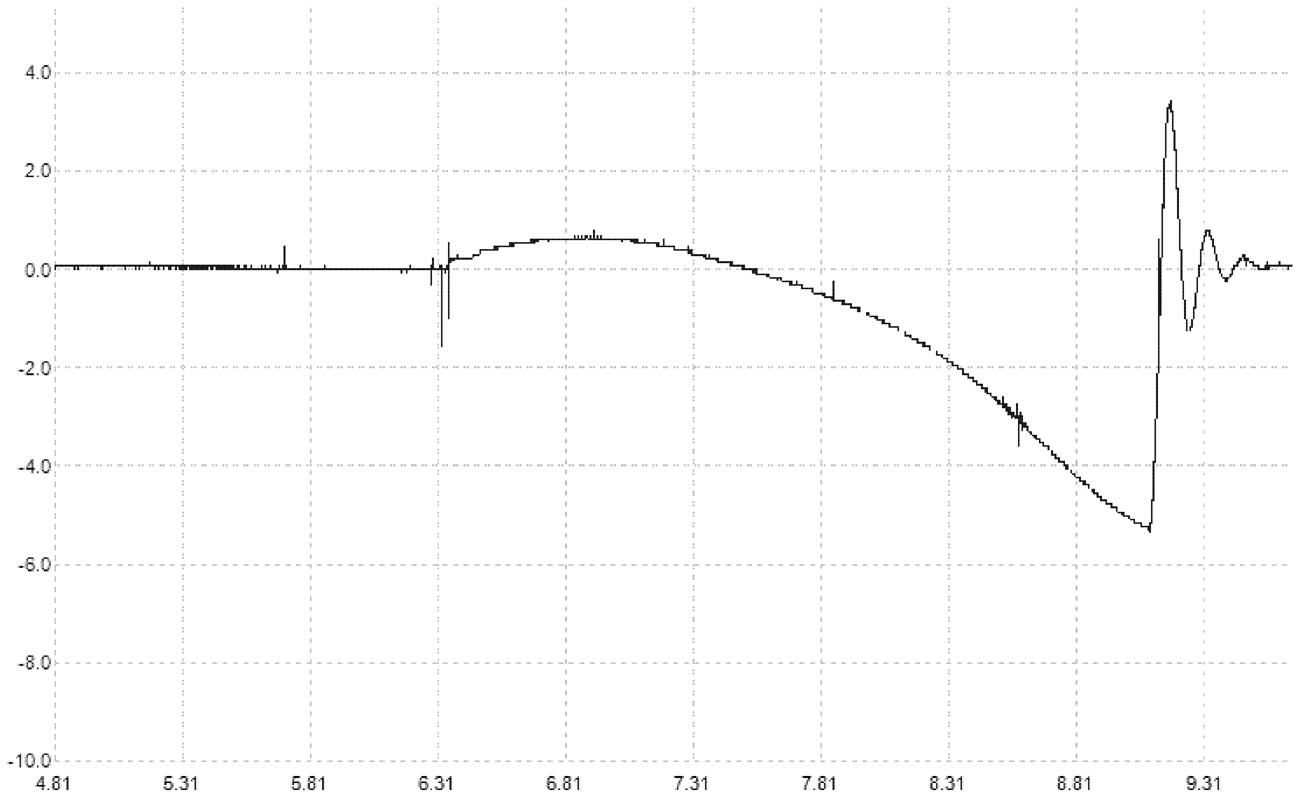


In normal operation, the flywheel spins around and produces voltage. When the timer closes, current will begin to flow in the coil. Where the timer closes the circuit in relation to the voltage waveform has quite an effect on how the coil will respond. I will show some graphs of the subsequent amp waveforms that result from the timer closing the circuit at various times. When the timer closes at “point 1”, it comes as close to duplicating a hand-cranked coil tester as is possible with a timer. The timer is closing right at the “null” or zero point of the waveform.



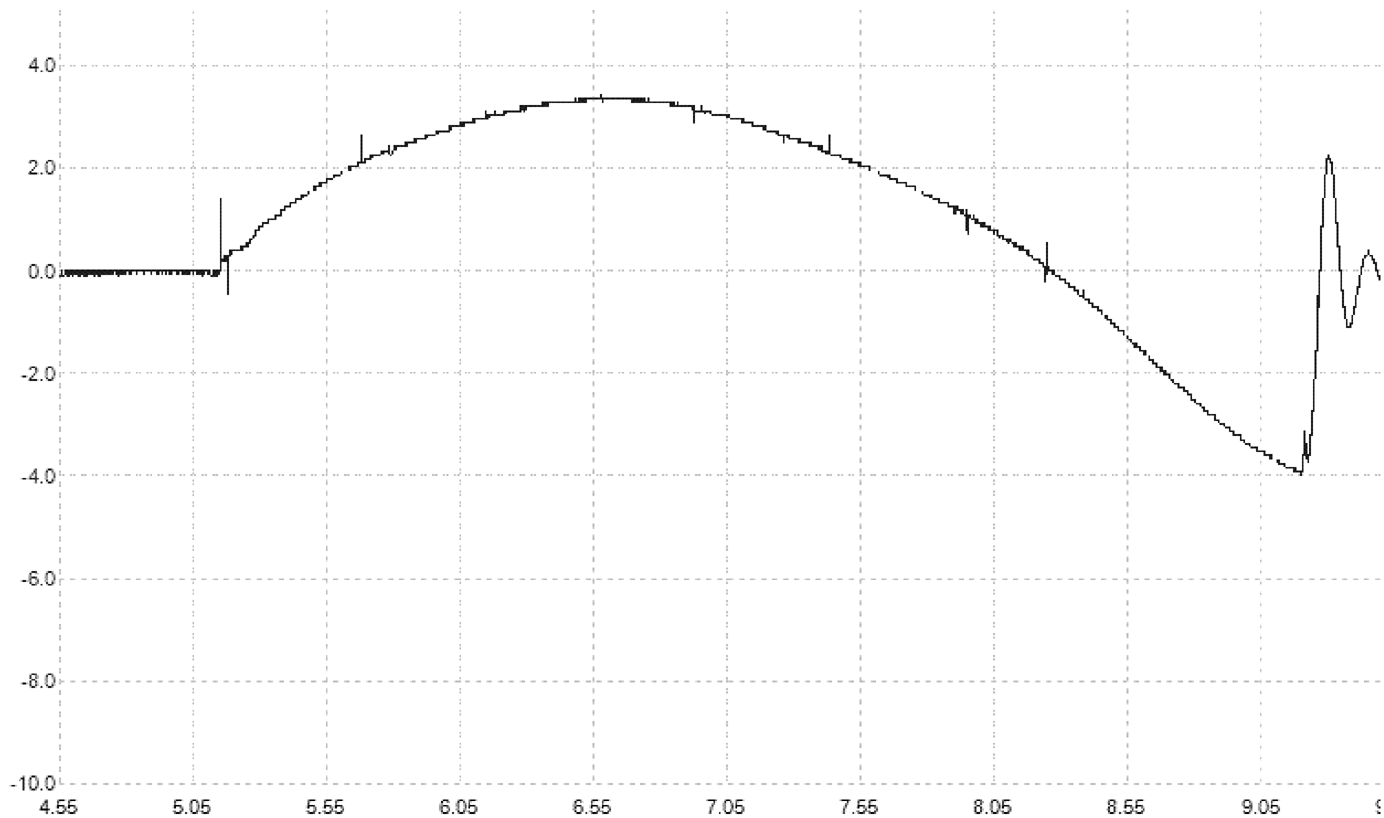
This graph corresponds to the timer closing at "point 1" on the previous voltage graph. In this and the following examples the flywheel is turning about 1100 rpm. At that speed each ms (x axis) is about 6.5 degrees. The timer closes at 7.1ms, which is near the null point of the voltage waveform. The amperage then builds to about -5 amps, at which point the coil fires at about 8.9ms. In this example we'll say that 8.9ms occurs 18.5 degrees before TDC (which is more or less, but not exactly correct). You will notice that the current rises to well over 5 amps, yet as shown above, the current barely rises above 4 amps when powered by a hand-cranked coil tester. This is because when the current is triggered by a timer, the coil doesn't "know" that it is being powered by AC. All the coil "sees" is a rising voltage. Until the voltage switches polarity (which it doesn't in this situation) the coil is effectively being operated on DC. The timer in this situation is in fact operating as a mechanical rectifier.

Time to fire: 1.8ms which equals 11.5 degrees.
Absolute fire time: 18.5 degrees BTDC
Timer advance from null point: 0 degrees
Spark advance from starting point: 0 degrees



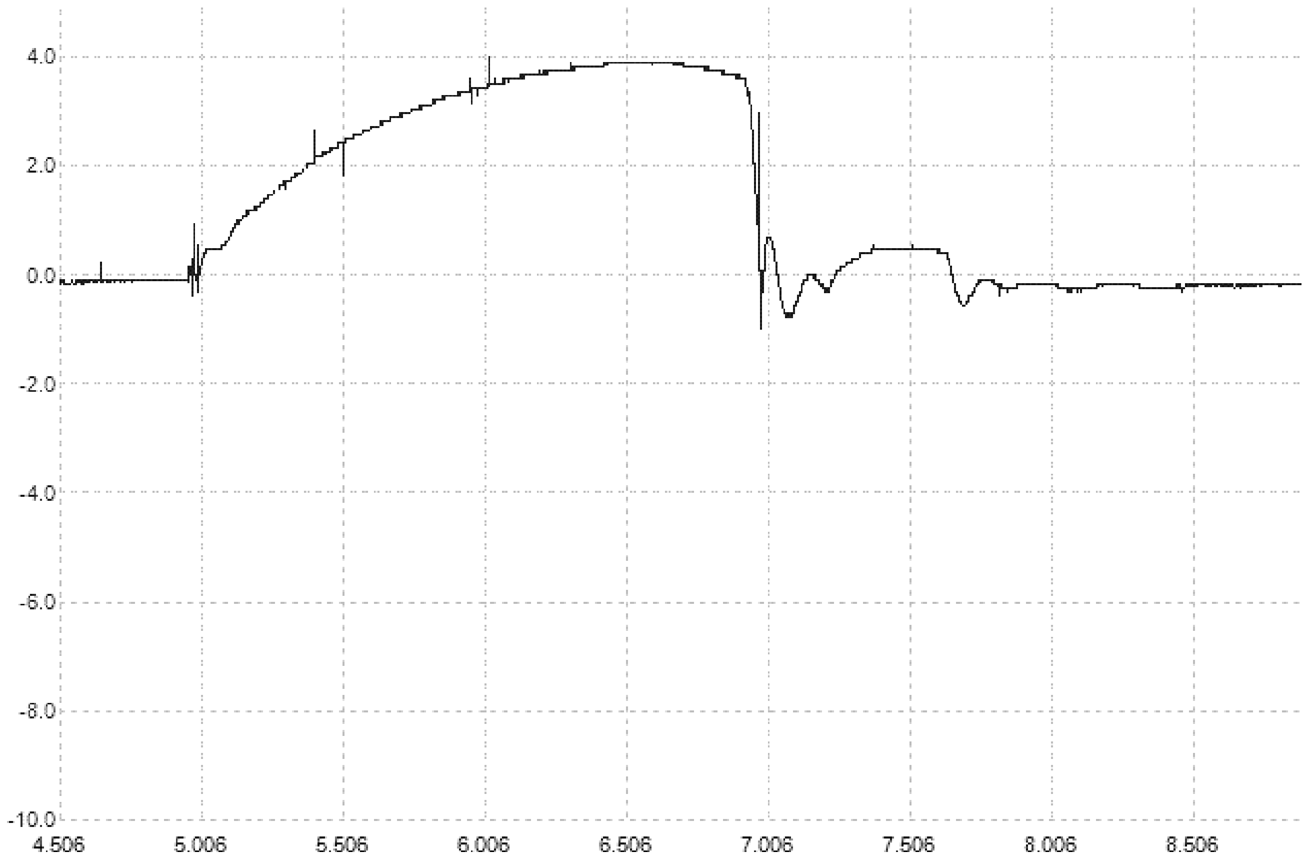
This graph corresponds to the timer closing at "point 2" on the voltage graph above. The timer has been advanced about 5 degrees and closes at about 6.3ms, which is about half way between the null point and the positive peak of the voltage waveform. The amperage builds to about 1 amp, which is not enough to fire the coil. The amperage then begins to build negative and the coil fires when the amperage reaches about -5 amps at about 9.1ms. 9.1ms occurs 17.2 degrees BTDC . The timer is advanced 5 degrees from the previous example, yet the spark is retarded 1.3 degrees. This is because the coil has to "undo" what it started to do. That is, the coil began to build positive, but ultimately fired negative, so the time spent building positive voltage was wasted.

Time to fire: 2.8 ms which equals 18 degrees.
Absolute fire time: 17.2 degrees BTDC
Timer advance from starting point: 5 degrees
Spark advance from starting point: -1.3 degrees



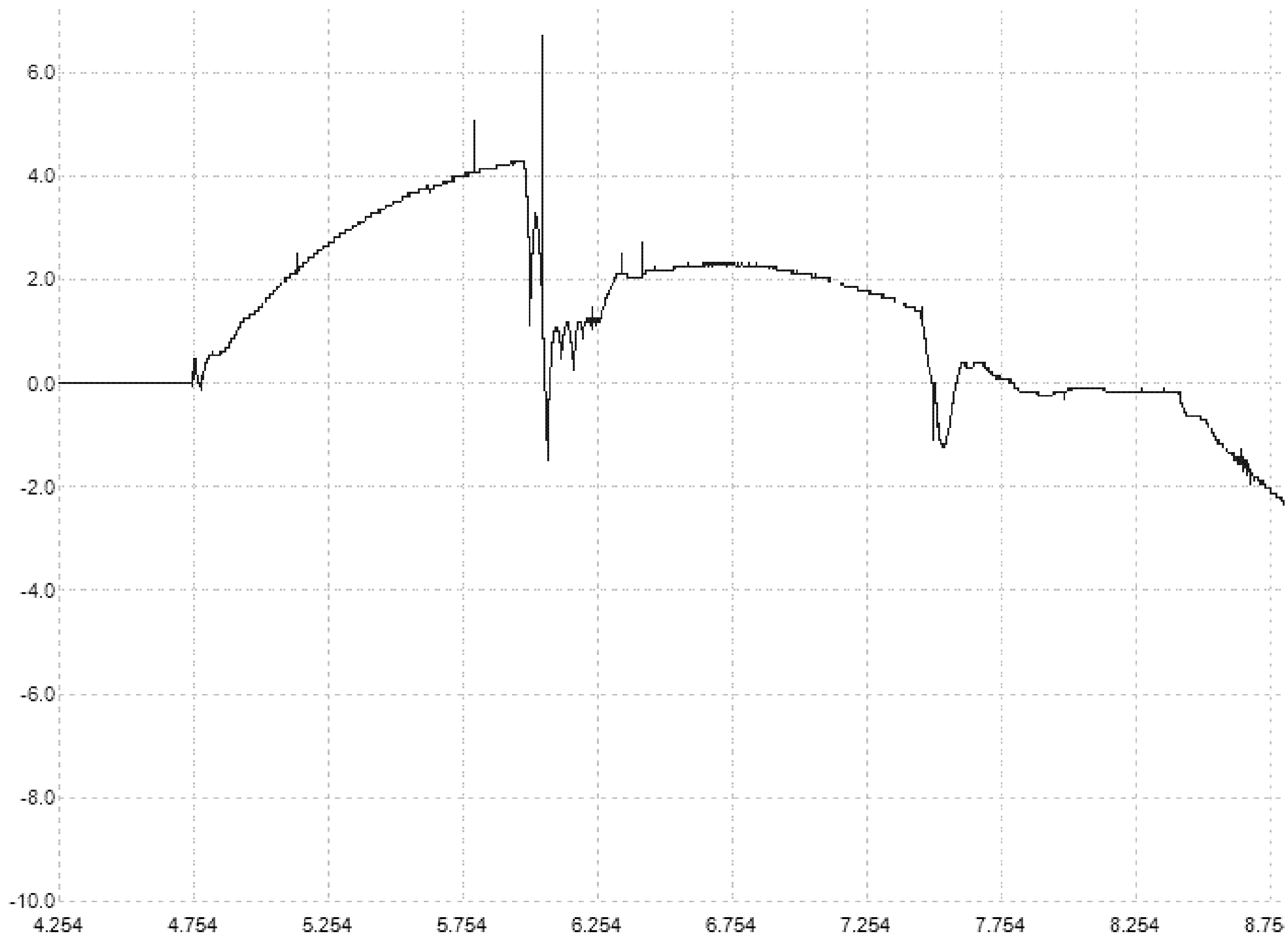
This graph corresponds to the timer closing near "point 3" on the voltage graph above. The timer has been advanced 12.2 degrees and closes at 5.2ms. The amperage builds to a little over 3 amps, which is not enough to fire the coil. The amperage then begins to build negative and the coil fires when the amperage reaches about -4 amps at about 9.2ms. 9.2ms occurs 16.5 degrees BTDC . The timer is advanced 12.2 degrees from the first example, yet the spark is retarded 2 degrees. This is the point of maximum disparity between timer advance and spark retard. Sometimes with the timer set at this point there will not be enough power in the mag to fire the coil from either the negative or the positive amp pulse. This is especially true if the mag is sub-par or the coils are poorly adjusted.

Time to fire: 4 ms, which equals 26 degrees.
Absolute fire time: 16.5 degrees BTDC
Timer advance from starting point: 12.2 degrees
Spark advance from starting point: -2 degrees



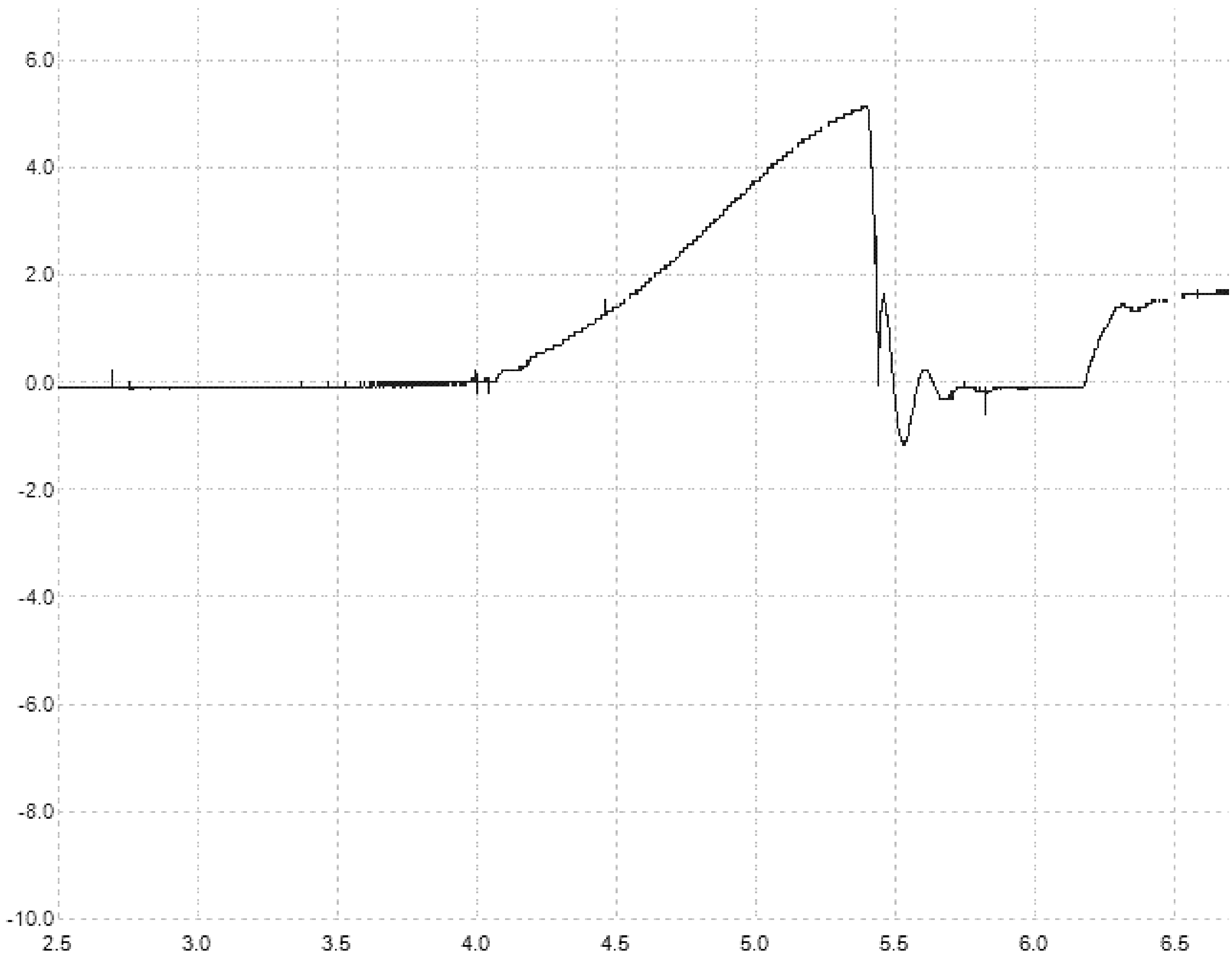
This shows the timer advanced about 1 degree from the previous graph. The timer has been advanced 13.5 degrees and closes at 5ms, which is right before the positive peak of the voltage waveform. The amperage builds to about 4 amps, which is just enough to fire the coil at 7ms. 7ms occurs 30.7 degrees BTDC . The timer is advanced 13.5 degrees from the first example and the spark is advanced 12.2 degrees. 1 degree of timer advance resulted in 14.2 degrees of spark advance. The coil is now firing on the positive pulse, but the spark has not quite caught up to the timer.

Time to fire: 2 ms, which equals 12.8 degrees.
Absolute fire time: 30.7 degrees BTDC
Timer advance from starting point: 13.5 degrees
Spark advance from starting point: 12.2 degrees



This graph corresponds to the timer closing at "point 4" on the voltage graph above. The timer has been advanced 15.5 degrees and closes at 4.7ms, which is between the positive peak and "null point" of the voltage waveform. The amperage builds to about 4 amps which fires the coil at about 6ms. The timer is advanced 2 degrees from the previous example and the spark has advanced 5 degrees. Of all examples presented in this article, this one has the fastest time to fire. When the timer is in this position the spark has advanced more than the timer.

Time to fire: 1.3 ms, which equals 8.3 degrees.
Absolute fire time: 37 degrees BTDC
Timer advance from starting point: 15.5 degrees
Spark advance from starting point: 18.5 degrees



This graph corresponds to the timer closing at "point 6" on the voltage graph above. The timer has been advanced 22.5 degrees and closes at 3.6 ms, which is near the null point of the voltage waveform. The amperage builds to about 6 amps, which fires the coil at 5.4ms. This is the same situation as the first graph in this series, except the voltage is reversed.

Time to fire: 1.8ms, which equals 11.5 degrees.
Absolute fire time: 41 degrees BTDC
Timer advance from starting point: 22.5 degrees
Spark advance from starting point: 22.5 degrees