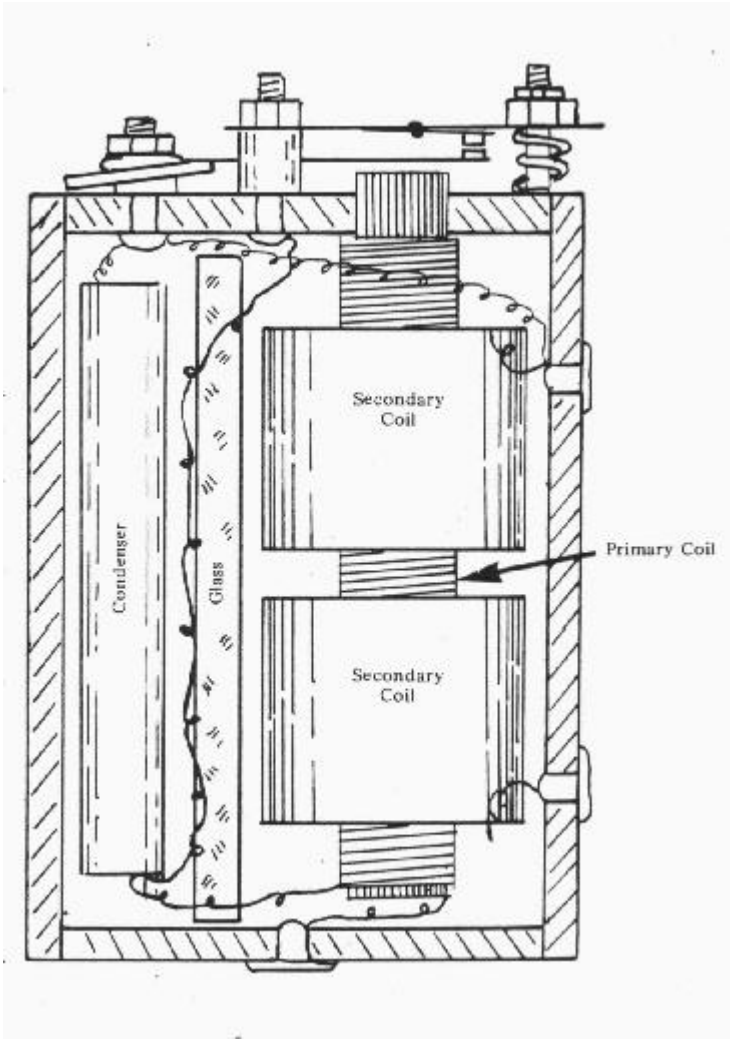
Know your Coils -
A Guide to Restoration and Adjustment of Model T Ford Ignition Coils.

This document has been adapted from one which was originally written by John Hunter in Australia (see https://www.cool386.com/fordcoils/fordcoils.html for his version). We have updated it, removed some unnecessary material and added our own views where we think they might be helpful to MTFRGB members restoring and adjusting coils, especially if they have the FACT (Ford Arduino Coil Tester) made available by the Register. Our contributions are in this blue font.

One of the most misunderstood aspects of the Model T is the ignition system.
The coils and timer system goes back to the Quadricycle, with the power source being battery only, until the Models N,R,S, which had the option of an accessory dynamo, and finally the T, which introduced the flywheel magneto. With nearly 16 million T's, and thousands of the preceding models using this system, one would have to be suspicious of claims of unreliability.
Being of such apparent simplicity, the method of operation and initial adjustment is a trap for the unwary. Simply assuming the coils are glorified door buzzers with a high voltage output, leads so many owners into trouble. Left frustrated and unable to get good results, a more familiar ignition system then gets installed. However, with the understanding of some key points, and a methodical set up procedure, the Ford ignition system is as effective and trouble free as any other.

Coil Rebuilding.
Unless they are new reproductions, coils will need to be rebuilt before use. They may well buzz and produce a nice fat spark, but this is just the start of the trap many fall into.
Firstly, the hundred odd year old internal capacitor, being of wax paper construction, will be leaky. Not necessarily leaky enough to prevent a spark being produced, but it will be leaky. This leakage may increase with temperature and voltage input to the coil, further compounding the problem. The end result is the output from the coil is not consistent and not as high as it should be. In the extreme case, the coil will buzz but be unable to produce a spark.
Secondly, the condition of the coil points and their setting is important. Incorrect settings can indeed provide a strong spark, but rough running is the likely result.
Some coils have open circuit high voltage windings. These will still often produce a spark as the high voltage jumps the break in the winding. However, not only is there a loss of high voltage for the spark plug, but the continual arcing between the broken ends of the winding will erode it away until the gap is so large that the coil fails to produce an output.
Before rebuilding a coil, the resistance of the secondary winding needs to be tested with an ohmmeter. Typically it should be around 3000 ohms. While reproduction windings are available, they are tricky to fit, and unless you have a set of the rarer coil types used in the very early cars, it's easier just to find another coil with good windings. If resistance measured across the two side terminals is infinite, the coil is effectively 'dead'. All other faults can be fixed.

How the coil works.
The 'door buzzer' approach is only a simplistic way of looking at coil operation. There is however, much more to it. Basically, energy is stored in the soft iron core of the coil and released at a controlled rate, through the high voltage winding and into the spark plug. The capacitor controls how fast this energy is released.



The amount of energy stored in the iron core is determined by how much current flows through the low voltage primary winding, and for how long. These factors are largely determined by the points adjustment and supply voltage.
First, let us examine the low voltage side of the coil. When current from a battery or magneto is fed into the coil, current flows through the primary winding of the coil. A magnetic field thus builds up around the iron core.
This magnetic field does not reach its maximum strength immediately, but takes a finite time, which is determined by a number of things, one of which is the coil current. The higher the current, the faster the magnetic field builds up.
If current is allowed to flow beyond the time at which the maximum magnetic field has built up (a few milliseconds), the core becomes saturated, and the energy is now wasted as heat. This is why we sometimes see a coil where the pitch has oozed from the casing; chances are the current was set too high.
The iron core has a secondary purpose which is to attract the lower vibrator point, thus interrupting the circuit before the core can become saturated.
Once the current is interrupted, the point springs back, completes the circuit and the process starts again. This happens about 200 times per second. Hence, the characteristic buzz.

The Capacitor.

With the sudden interruption of the current when the points open, the energy stored in the iron core

is rapidly released. Because the magnetic field collapses faster than it took to build up, the primary winding actually generates something much higher than the battery or magneto voltage. In fact, it's enough to arc across the points as they open. This is the points arcing seen on a Ford coil with an open circuit capacitor.

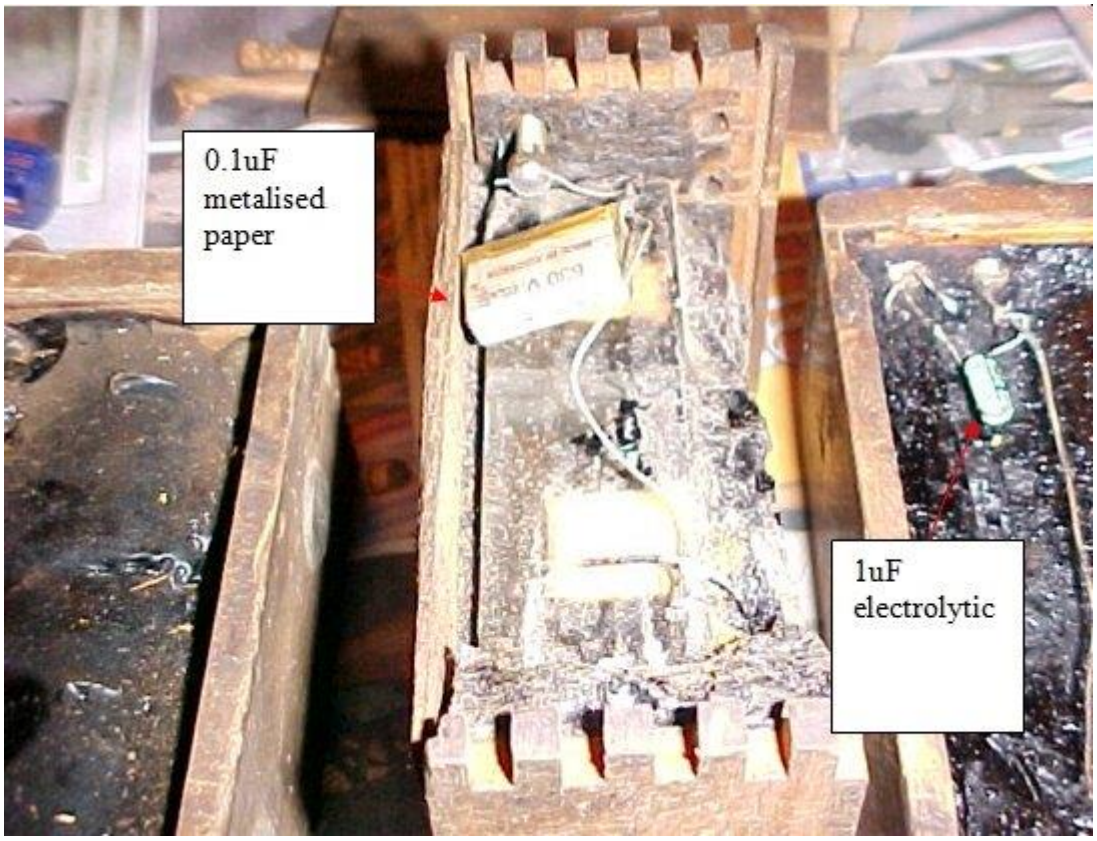
We can slow down the rate of magnetic field collapse by connecting a capacitor across the points. The capacitor absorbs the energy at a specific rate of time, and reduces the voltage across the opening points to a non destructive level. Typically, this may be around 300V when the coil is operating from a 6 volt battery. (Note that this figure was measured with a particularly good coil and others may differ!)

Needless to say, the value of capacitor is important as it not only affects output voltage but also points life. The capacity is 0.4 to 0.45 microfarads for KW coils and should be rated for at least 400 volts working.

Unbeknown to most T owners who have attempted to replace coil capacitors is another very important rating. This is the dv/dt rating, which is the rate of voltage change over a specified time period. Put simply, if the capacitor is forced to charge too quickly it will overheat and fail.

The Ford coil requires a capacitor of at least 600 volts per microsecond. That is, if you were to charge the capacitor up to 600 volts in less than one microsecond, the rating would be exceeded and it will eventually fail.

Ordinary polyester capacitors sold by most component suppliers like Jaycar and Altronics, are rated at about 100 microvolts per second. This is why so many folk experience failed capacitors when attempting to rebuild coils, even if the correct capacity and voltage ratings have been used. Suitable replacements will be discussed later.



Unfortunately, most coils in the past have had completely unsuitable capacitors installed by owners not familiar with coil operation. This is one reason for the prolific amount of cars today fitted with distributor ignition.

How is the Spark Plug Voltage Produced?

Having produced our pulses of 300 odd volts across the primary winding, simple transformer action is used to step this up. A secondary winding of many more turns is wound over the primary. The collapsing magnetic field will therefore induce a higher voltage, the value of which is determined by the ratio of the number of primary turns to the number of secondary turns. The primary winding of a typical KW coil has 212 turns and the secondary winding has 16,600 turns. Thus the turns ratio is 78:1. Now, what happens when the 300V is stepped up 78 times? The magical figure of 23,000 volts is produced; more than enough to reliably jump the gap of a spark plug under compression.
The astute reader may wonder about coils with an open circuit capacitor and why they fail to produce output. After all, with much higher voltage across the points shouldn't this in turn produce a greater spark plug voltage? In theory, yes, but when air ionises and breaks down it forms an arc at those opening points. The voltage across the points gap then drops considerably because an electrical arc is a conductor.

Most of those intending to rebuild their coils will be glad to know that the technical information presented so far is not actually necessary, but it does illustrate why it is necessary to rebuild original coils and with the correct capacitor.

Preparing the Coil for Rebuild.

I find a scouring pad good for cleaning the wood surface to get old dust and grime off it. If the coil has been painted this could cause problems, if the paint has a conductive pigment. Therefore, it should be removed from around the terminals and points mounting nuts. PVA glue is ideal for repairing the wooden parts, if required.
To access the internals, it is first necessary to remove the two or three panel pins at the bottom of the coil box. The lid should just slide downwards, unless it has been stuck in position by the pitch inside the box. If so, gently prying will usually release it. In some cases it's necessary to break apart the box but this isn't as drastic as it sounds because it will usually come apart cleanly at the joins.
The messy part comes with removing the pitch around the capacitor. The capacitor occupies the entire length of the box on the left hand side. Immediately to its right is a strip of wood or a piece of glass used to insulate it from the actual coil windings. The old capacitor must of course be removed. Depending on the size of the new capacitor, the insulating strip of wood or glass also needs to be removed. It is no longer required when a new plastic bodied capacitor is installed.
Be careful not to damage the coil windings with whatever implement is being used to dig them out. In the process, pieces of pitch will fly everywhere and stick to everything. It is better to chip out the pitch cold rather than to heat it for it will come out in chunks rather than a gooey mess.
The easiest way is to simply prise off the side of the box next to the capacitor. Dig down to the old capacitor next to the side, then lever the side off against the capacitor. The side should come off cleanly at the finger joints, since it is not glued. Once the old capacitor is out, the side can be replaced, using PVA glue to secure it.
As the capacitor is extracted, cut off its two connecting wires close to the body; one at each end.

Removing the Nuts.

Next, remove the points assembly; this involves removing all the nuts on the top of the coil. Unfortunately, removing these nuts can be problematic because they are often rusted tight, particularly on coils stored in less than optimum conditions. The nuts are available from the usual parts suppliers, but unfortunately the screws are not, and they are of an obscure thread (12-32UNF). The adjusting stud and nuts are the more common 10-32UNF. Important to note is that the only thing stopping the screw turning is a square shaped chamfer under its head. If the screw is forced, this wears away the keyway in the wood making the screw even looser. CRC and the like can

sometimes help free the nut, but often it has to be ground off. If the screw is one with a connection to the internal wiring, the soldered joint inside will often fail when the screw is forced when trying to undo a stubborn nut.
With early brass top coils, see that the insulators are in good order, otherwise the points might be shorted out.

Capacitor Replacement.

As explained previously, there are very few capacitors suitable for use in Ford coils. The original capacitor has a value of 0.4 to 0.45 microfarads. The nearest value available today is 0.47 microfarads which is well within tolerance.
It is futile obtaining the capacitor from any of the usual hobby type electronics part suppliers because it will have insufficient dv/dt rating, and will eventually fail, no matter how high the working voltage. While points capacitors used for distributor ignition systems may look enticing, they have inadequate dv/dt rating. Electrolytic capacitors are the worst possible type one could choose. Not only are they for DC only, but are completely unsuitable for pulse circuits and will fail immediately.
There are only a few kinds of capacitor which are suitable. The first is a polypropylene type available from Farnell and other specialised suppliers. However, its dimensions make it awkward to fit inside the box and it is rather expensive.
The best type of capacitor is a Sprague “Orange Drop” which is available from several Model T parts suppliers; in particular Langs and Snyders and the MTFRGB. Unfortunately, some suppliers are still selling ordinary polyester capacitors which fail. Another type was also available direct from the no longer extant Fun Projects. Both types easily fit in the coil box.

Correct capacitors. At left is the Sprague type with a dv/dt of 700v/us, and at right is a type sourced by Fun Projects with a dv/dt rating of 1700V/us.

The story of why it is essential to use the correct capacitor was described further on the Fun Projects site. Essentially, the capacitor has to be able to tolerate a very high voltage within a very short time.

Again, I need to emphasise incorrect capacitors will end in frustration. Provided the correct type is used, the coils will happily operate from a 30V magneto for a lifetime, without the capacitor failing. Installation is simply a matter or connecting its leads to the wires cut off the old capacitor. The joints should be twisted before soldering, given the vibration the connections will be subjected to. I don't advise re potting the capacitor until the coil is tested, just in case there are other faults.

Points Checking and Replacement.

Because the coil box wood is soft, it may have been noticed that the two cylindrical spacers used to support the upper point have sunk into the wood, likewise the attachment of the lower point bridge. Leaving things in that condition will prevent correct point alignment, but one can simply pack up the depression in the wood with washers to restore the original level.

The screws and nuts need to be cleaned of rust because this can result in non operation of the coil.

The point gap adjustment nut (the one everyone fiddles with when they shouldn't) has fibre washers to separate the spring from the upper contact.

If they have crumbled away they will need replacement. The fibre washer is not strictly necessary with the wooden top coils, and a steel or brass one can be used instead. We have found that it is better to have no washer above the upper bridge. Brass top coils do require the fibre washers, otherwise the top of the coil will be connected to the upper point and short out.

Old points can be reused provided pitting is not severe and most of the contact surface is present and the points are not very thin – the hardness appears not to be full depth. It is possible to clean them up for a new lease of life, but any filing must be done as squarely as possible, otherwise the full contact will not be made, resulting in overheating and erosion of the small part that does make contact.

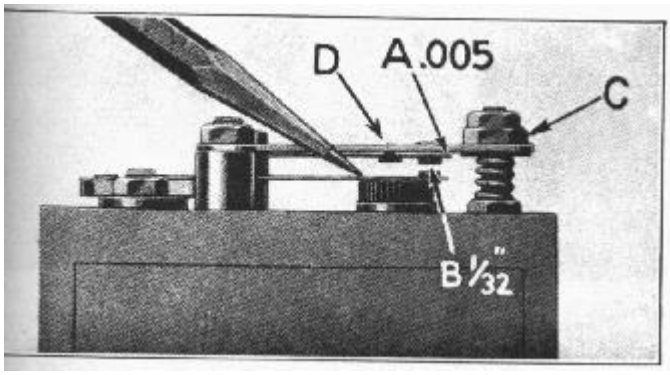
Given that new points are inexpensive, it is worth replacing them when rebuilding a coil unless the old ones are in excellent condition. New points are available from the usual Model T parts suppliers, as are other parts for the coils. Points and Sprague type capacitors are available from the MTFRGB

Installing the Points.

Replacing the points is straightforward enough, but if the screws securing them to the box keep turning or need replacement, now is the time to deal with it. These screws are of an obscure thread (12-32UNF) but replacement nuts are available. If authenticity is not important they can be re threaded or replaced with something more convenient.

When screwing down the nuts, see that the points are set squarely. This is done by holding down the upper contact, against the lower contact and seeing that the two contacts are fully touching.

Next, the points gap adjusting nut can be set (point C in the diagram). To do this, hold down the lower vibrator contact until it touches the iron core. Using a feeler gauge, screw down the points adjusting nut until the upper vibrator contact has a 0.031" clearance. This is just a start setting.



The cushion spring is the final static adjustment. Here, with the lower contact held against the core, there needs to be about 0.005" between the cushion spring and the upper vibrator, shown at point

A. This is achieved by slightly bending the upper vibrator which can be done by gently tapping on point D.
Note that the points are horizontal with respect to the coil casing. Often, the spacers for the upper contact have sunk into the soft wood. Use 5mm washers to restore the correct spacing. If the lower contact cannot be made horizontal, chances are the iron core has migrated upwards. One way to restore its correct position is to heat the coil by passing a few amps through the primary winding, and then pushing the core back.
Unless the coil geometry is correct to start with, it will be very difficult to adjust it for correct operation.

Once the points have been statically set it is now time to set the current and check for double sparking. This is an area where many run into trouble, again resulting in frustration and discarding of the original ignition system. Suitable test apparatus is required, and there is no shortcut.

Electronic Testing.
In view of recent technology, the superior method of electronic testing is now possible. The Model T owner may investigate the ECCT; the Electronically Cranked Coil Tester. This device allows coils to be set so they all fire equally, and without multiple sparking. For the technical user, the instrument provides a detailed coil analysis. Furthermore, those with a magneto can properly test that too. All in all, it's a comprehensive Model T ignition diagnostic tool.

The FACT device was developed by people using the MTFCA Forum, notably 'Matt' in California and 'Luke' in New Zealand for DIY enthusiasts. Its functions are very similar to those of the ECCT (but no magneto test).

"Buzz Box" Coil Testers.
Familiar to many, these simply consist of the coil being placed into a jig which connects it to a battery via an ammeter. A spark gap is provided to load the coil and simulate a spark plug. These devices have their place and can be useful, provided their limitations are understood. This method of testing will not allow the user to eliminate multiple sparking, nor can equal firing time to be adjusted. In short, this kind of tester can get coils going in an emergency, or be used as a basic go/ no-go test, but it is important to remember that the car's performance is unlikely to be optimum as a result of adjusting coils this way.
A Buzz Box coil tester is not recommended for accurate adjustment, but will get the car drivable.

Coil still Faulty?
In some instances a rebuilt coil fails to work. There are several things to check here. Most common is rusty nuts preventing good connection between the point assembly and internal wiring. One instance I encountered was where the new points looked perfect but one of the actual points was found to be insulated from the vibrator spring. It had simply not been riveted tightly during assembly. Dry or broken solder joints to the points mounting screws are another common fault. These should be inspected closely when installing the new capacitor.
Another possible problem is the connections to the three brass terminals on the side of the box. Two problems can happen here. One is with the soldered joints. Sometimes the enamel was not completely stripped from the winding wire when the coil was manufactured. While the solder looks like it has completely covered the terminal, removing it will show up if this is the problem. Ensure the solder takes to the actual wire when resoldering these terminals. Another fault is often really to do with the coil box in the car and how the coils fit into it. It can be that the contacts simply do not make good contact with the coil terminals because of warpage of wood, etc. This is often the cause of "it works in the tester but not always in the car".

Open circuit secondary windings are possible but not common. Unfortunately, some open circuit secondaries have been the result of over zealous capacitor removal. It's a very fine wire, so be careful.

Battery Only Operation.

Operating conditions for coils are quite different on DC (battery) and AC (magneto).
A word on battery versus magneto operation would be pertinent at this point. Suffice to say, with attention paid to a few points, battery operation is satisfactory, and one should not feel unable to use the Ford coils if the car does not have a working magneto. Conveniently, the ideal operating voltage on DC is 12V. Running on 6v results in much longer 'time-to-fire' and the timing has to be advanced considerably to get power.
Migration of the contact material from one point to another has been claimed to be a problem with DC operation, with the result being one point loses material to the other. It has to be questioned under what circumstances these claims have been made, because my observations are that on 6V it occurs at an insignificant rate, probably on par with magneto operation, but is more prevalent on 12V. Even then, it is so gradual as to be practically irrelevant, and this has been proven by a number of cars in the club. At this point in time, I have covered nearly 30,000km with my original coil points running on 6V. They are still in excellent condition.

Re-potting the Capacitor.

If all has gone to plan, and the coil is now working and set correctly, the capacitor needs to be secured. One can re use the old pitch by melting the pieces in a tin can over a weak blowtorch flame. However, there will not be enough to fill the entire void unless one has saved the pitch from other defective coils, but it is usually enough to secure the newer, smaller capacitor. Another method is to use expanding foam This can easily be cut away with a knife if repairs have to be made in the future, but is quite rigid when set. However, it is much better to cut one or two small pieces of wood to fill in the gap between the coils and the side of the box, then pour some molten old tar back to hold everything.
Provided the coil restoration has been done correctly, they should be faultless for many years, with possibly a check on a coil tester every few years to see that contact adjustment is still optimum. There have not been any reports of the proper high dv/dt capacitors failing.

Plastic Coils.

Plastic coil with two kinds of capacitor that may be found inside.

Information on these coils is non-existent. They appear to be still manufactured. What I have been able to determine is that the capacitor value is too low at 0.1uF. Primary coil inductance is less than the wooden coils, and the peak current is higher.
To use these in your Model T, the capacitor needs to be replaced with the correct 0.47uF high dv/dt type. It would appear these coils are designed for 6V operation. To get rid of double sparking, when setting these coils on the ECCT, it seems best to adjust for a shorter firing time; about 3 or 4 degrees earlier. (Note that the ECCT operates at 12V).
In terms of construction, these coils are very good - except of course the capacitor is the usual weak point, being the wrong type. However, because they have different characteristics to the wooden coils, they should not be mixed. The coil set in a car should either be all plastic or all wood; not a mixture of types. I have no experience with plastic coils operating from a magneto.
Replacing the capacitor is easier than the wooden types, since it is smaller. Also, the plastic doesn't come apart or warp. The lid is secured simply by using the hot pitch as an adhesive when the coils were assembled. After replacing the capacitor, the lid can be secured by using silicone sealant around the edges and smeared over the pitch.

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Amendments – Chris Barker & John Housego

Issue 2 with minor correction July 2026