

Model T

Ford Arduino Coil Tester (FACT)

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DRAFT 5/29/22

Basic Electrical Tests

Perform the following tests to diagnose and fix issues detected. Capacitance can be verified by using a multimeter on the high resistance setting and watching reading move slowly then reversing leads to see the same or a capacitance tester. It may be desirable to do Basic Mechanical Adjustments (i.e. remove/replace points) before completing these tests.

Ford Model T Coils - 1913-1927

Connections/ Ohm Readings

A-B: $\infty \Omega$ (w/points open)

A-C: 0Ω

A-E: 0.295Ω (w/points closed)

B-E: 0.295Ω

C-D: 3300Ω

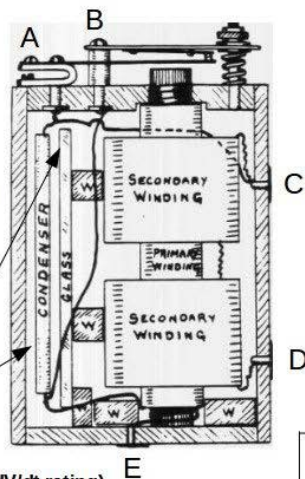
Note: Connections at A and B are sometimes reversed (more common on K-W coils).

Condenser

$0.40-0.45 \mu F$

replacement capacitor spec:

$0.47 \mu F$, $>400VDC$, $>600V/\mu sec$ (dV/dt rating)

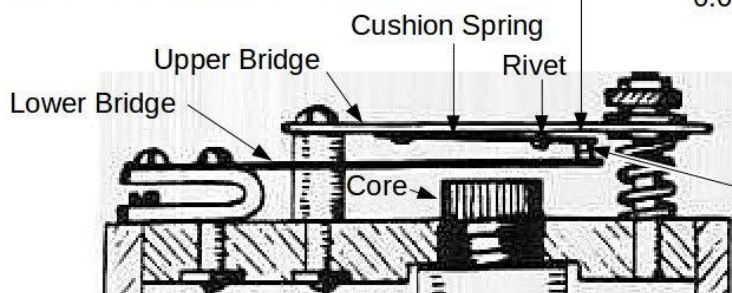


Problem Causes - Symptoms

- **Condenser Open** – heavy blue arc on points but no spark (A-B $\infty \Omega$ w/ points open)
- **Condenser Shorted** – no arc on points, no spark and irregular current draw (A-B 0Ω w/ points open)
- **Secondary Coil Open** – points vibrate and no spark (C-D $\infty \Omega$)
- **Secondary Coil Shorted** – points vibrate but irregular spark (C-D 0Ω)
- **Primary Coil Shorted** – points don't vibrate and irregular current draw (B-E 0Ω)
- **Primary Coil Open** – points don't vibrate, no current draw and points are clean/adjusted (B-E $\infty \Omega$)

Cushion Spring Gap:

(cushion spring touching rivet head with very light pressure, make all four coils the same gap)
 $0.003-0.005"$



Point Gap:

$1/32"$ or $0.029-0.031"$
(with lower bridge pulled down to core)

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Results: To record multiple coils use a table in the appendix. (Figure above [drawn by John Carter.](#))

Test	Desired	Results	Comment
A-B (w/Points open)	$\infty \Omega$		
A-C	0Ω		
A-E (w/Points closed)	0.295Ω		
B-E	0.295Ω		
C-D	3300Ω (Ford) 2100Ω (some KW)		
Point Gap	$1/32"$		
Spring Cushion	0.005		
Condenser	$.47 \mu F$		
Current Draw	1.3 Amp		

Comments:

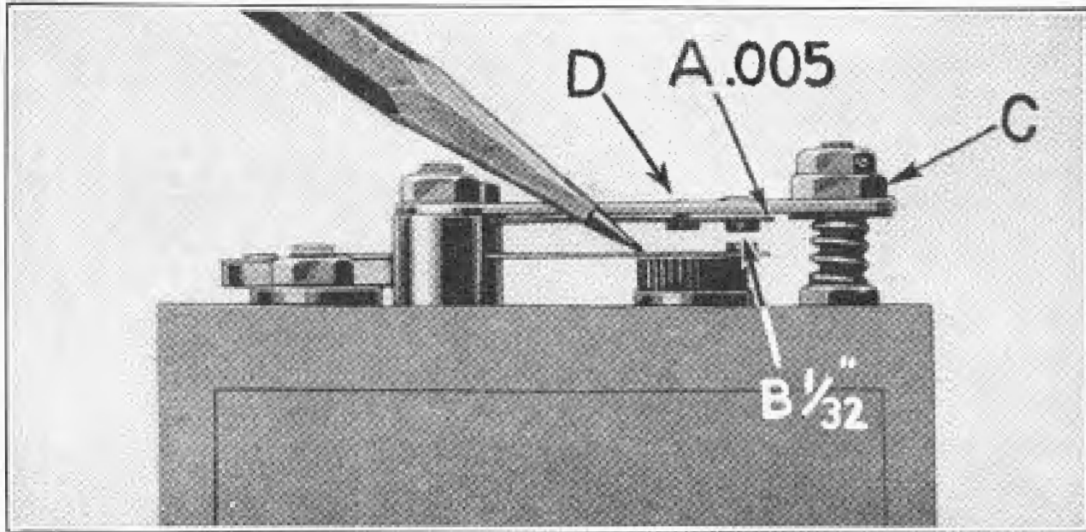
Basic Mechanical Adjustments

The following are the basic mechanical adjustments needed for a coil. It is a good idea to electrically test coils to verify that you have a rebuildable coil before proceeding.

1. Disassembly

- Clean all bolts with a wire brush/wheel to remove rust and dirt.
- Add favorite oil to threads and allow to set overnight.
- Gently loosen nuts. Use care to not turn studs as they are electrically connected internally. If nuts are too stubborn they can be carefully ground/cut off.
- Clean all studs, nuts and determine usable hardware.
- Before moving forward, this would be a good time to test/replace electrical components including the capacitor. See Basic Electrical Adjustment section.

2. Cushion Spring Gap



- Set Cushion Spring Gap
 - Ford recommended .005" clearance for the full length of the spring.
 - See [Ref 13](#) for more details from Original Ford service manual.
 - Many new points have .020" travel.
 - If cushion spring is not the correct clearance the following two methods can be to remedy the problem.
 1. Gently smash down rivet with hammer.
 2. Using either modified vice grips (see [this reference](#)).
 - Be careful, if you go too far you will have no clearance.

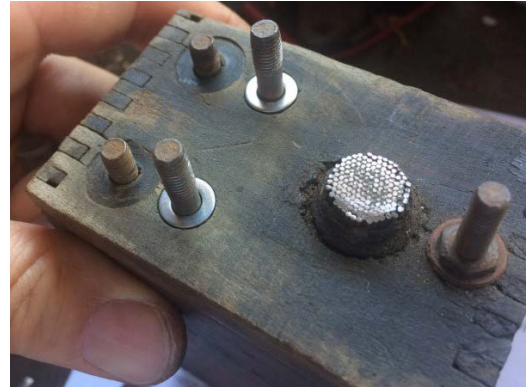
3. Polish Points

- Use a wet stone or wet/dry sandpaper to clean/polish points.
- If deep peaks and valleys use a coarse grit then go down to 1000 grit.



4. Install Points

- Add shims under points if hardware has sunk into wood.
- Points should come together flat, as seen in image on step 2. If not, shims (washers) can help.



5. Replace Capacitor

- Coils with original capacitors can be found with 0.1 to 5 μF .
- It is recommended to replace original capacitors.
- Replacement of capacitors is an involved process that requires caution in carefully removing tar, soldering wires with replacement capacitors and repotting with tar.
- Because of the work involved it is attractive to have a set of coils refurbished by a skilled rebuilder for a couple hundred dollars, but then that would make most of the recommendations here not relevant.

6. Set Point Gap

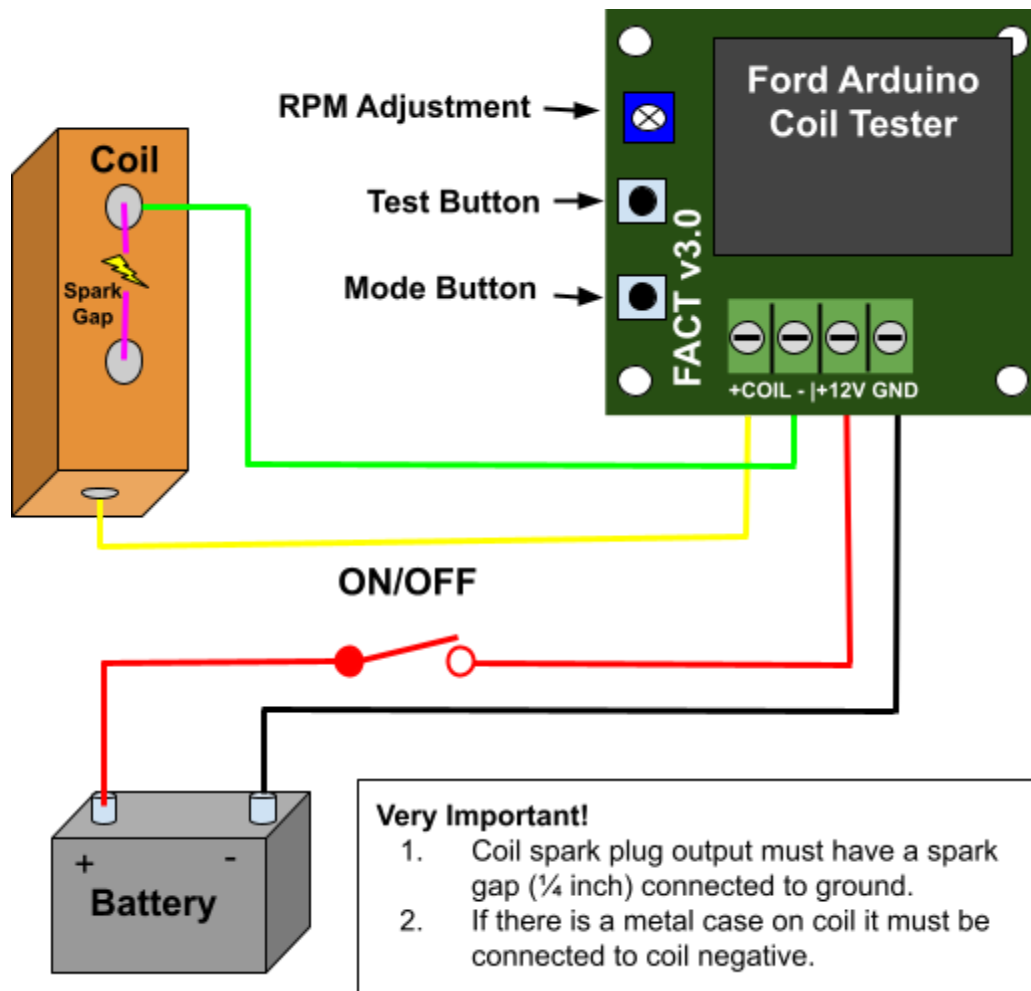
- Ford recommended that points be set to 1/32" (.031") gap when the coil spring is pulled down.
- This can be done with a feeler gauge or use a small paper clip (of correct diameter).

7. Set Spring Tension

- It is recommended that the current be set to 1.3 A @ 6 Volts by adjusting tension.
- Tension can be set by gently prying and hammering on the lower bridge.

Testing with the Ford Arduino Coil Tester (FACT)

Please refer to the following pictorial diagram for connecting the Ford Arduino Coil Tester:



Simply put, the FACT coil tester is an oscilloscope that graphically displays the time to fire and current consumed by the coil. The FACT does this by sending an electronic pulse for 50 ms.

The following are the test modes:


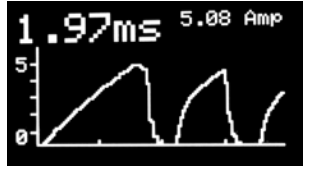
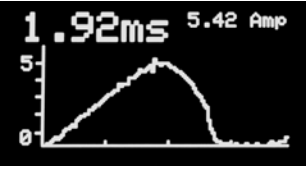
- **Single Fire-** graphs current and displays time-to-fire and maximum current measurements.
- **Live Oscilloscope-** displaying overlapping waveforms and average time-to-fire and maximum current measurement.
- **Bar Graph-** displaying time-to-fire measurements as a bar graph.
- **Multiple Fire-** statistical information on time-to-fire measurements
- **Capacitance-** test coil and continuously displays capacitance and series resistance of capacitor.
- **Capacitance graph test-** displays charging curve for capacitor then displays capacitance and series resistance of capacitor.

Dynamic Coil Adjustments

To fully test a Model T ignition coil it must be dynamically tested. Originally the Hand Crank Coil Tester (HCCT) was used. In the 1960s oscilloscopes were used in testing mechanical points on distributor testers. In the 1980s, there is evidence that people were using oscilloscopes to tune model T ignition coils. In the last few decades, a few alternatives were made available (i.e. Strobo-Spark, [ECCT](#), and now the [Ford Arduino Coil Tester](#)). Ultimately the goal is to create four *matched* coils that produce sparks with similar dwell and spark intensity over a wide range of engine speeds. All of these products have been used successfully. The FACT uses both the visual display of the oscilloscope and time-to-fire concept. Use the following steps to test a Model T coil using the FACT.

1. Connect to a 12 volt power supply. (8-18 VDC okay. A regulated power source is desired for consistent results.)
2. Turn on power to FACT.
3. Place the coil in the tester.
4. Press the **Mode button** on the FACT tester to select one of the following tests.
5. **SINGLE FIRE TEST**

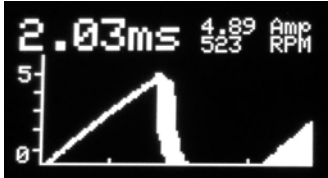


- a. Press the **Test button** for a single fire test.
- b. Examine the waveform:

		
Good waveform. Nice ramp with clean drop off.	Double Spark caused by improper adjustment of cushion spring.	Bad Capacitor causes faulty waveform.

- c. If the waveform is good, adjust the spring tension to get the desired time-to-fire (e.g. 2 ms with 12 VDC source). The goal is to get a set of four coils with the same time-to-fire value.
- d. If there is a double spark, adjust the upper bridge cushion spring.

6. LIVE O-SCOPE

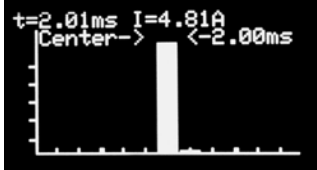


- a. Press the **Test button** for the continuous fire oscilloscope test. This will repeat the single fire test and give overlapping waveforms.
- b. Examine waveform:

		
Good waveform Waveforms overlap with narrow lines and a new waveform is just starting on the far right.	Double Spark causes lots of overlapping waveforms after the initial ramp.	Bad waveform Lots of inconsistent overlapping waveforms.

- c. The rpm may be adjusted using the potentiometer for this test.

7. BAR GRAPH TEST

- Press the **Test button** to display the time-to-fire as a bar graph.
- Examine waveform:

		
Ideal It is desirable to have all the time-to-fire measurements in a single 0.1 ms column.	Okay If the coil is a bit erratic some of the measurements will fall in the adjacent columns.	Bad Very erratic measurements will lead to data in many different bars

- The center position may be adjusted using the potentiometer for this test.

8. MULTIFIRE TEST

- Press the **Test button** to display the time-to-fire statistical data. This will continuously display and update statistical measurement.
- Press the **Test button** a second time to end the test.
- The speed (rpm) of this test is controlled by the potentiometer. If the speed was faster/slower than desired, adjust to desired speed in rpm. Most coils the speed doesn't change the outcome of the measurements, so it is suggested to set fully clockwise to measure at full speed.
- Examine test results:

```

t=2.00ms #34
(Min=1.95 - Max=2.05)
SD=0.02; Dwell= 0.23°
Max Current= 5.03amps
390 RPM 0 MISFIRES




```

- Verify statistics are desirable

Parameter	Description
t	Average time to fire in milliseconds. Numbers in the parentheses are the maximum and minimum values.
SD	Standard Deviation. The smaller the value the higher the precision, so a small value is desirable.
Dwell	Degrees of dwell. Determined by the range between max and min time-to-fire and answer is in degrees of rotation.
Max Current	Average of maximum currents measured.
RPM	The speed may be adjusted using potentiometer for this test.
Misfires	The count of the number of times the current didn't reach a threshold to be considered acceptable.




9. CAPACITOR TEST

- Hold points with a piece of paper.
- Press the **Test** pushbutton.
- Review graphical analysis:



		
Good Capacitor.	Points Closed. Points must be opened for testing. (Place a piece of paper in points for testing.)	Bad Capacitor causes the background to reverse. (Note in this case the capacitor is larger than normal.)

10. CAPACITOR GRAPH TEST






- Press the **Test** pushbutton.
- Review graphical analysis in first display:

		
Good waveform. Note that the waveform traces the ideal waveform (dotted line).	Points Closed. Points must be opened for testing. (Place a piece of paper in points for testing.)	Bad Capacitor causes faulty waveform. (Note in this case the solid line below the dotted line.)

- Detailed analysis in follow-up display:











		
Good capacitor is in the prescribed range.		Bad Capacitor causes faulty waveform.

Appendix #1 - Purchasing Parts to Build the FACT

Image	Description	Price
	FACT PCB Order from jlcpcb.com using files found on the MTFCA forum discussion .	\$5-10 (depending on quantity)
	Arduino Nano Every Recommended, but Arduino Nano or generic Nano should work fine as well.	\$10
add	1.3" OLED Display Module Board SH1106 Important must have all the following <ul style="list-style-type: none"> Pin order must match the image: VCC, GND, SCL, SDA. 128 × 64 dot matrix display I2C IIC serial communications 	~\$10
	.96" OLED Display Module Board SSD1306 (alternative to 1.3" display above) Important must have all the following <ul style="list-style-type: none"> Pin order must match the image: VCC, GND, SCL, SDA. 128 × 64 dot matrix display (Yellow/Blue recommended) I2C IIC serial communications 	<\$5 (For generic.)
	Push Button (Quantity 2) Any single pole single throw (spst) momentary push buttons can be used. Recommended two different colors.	~\$2
	Toggle Switch Optional, but very desirable to turn on and off power and/or to select from different voltages. Double pole double throw (dpdt) recommended.	~\$1
	Hook-Up Wire Note: Use 16 - 18 AWG to work properly. Four color silicon wire with fine strands is recommended.	
	Alligator clips - Black and Red recommended.	
	Electronics Box to hold electronics and test coil.	
	Tuning Tools	

Appendix #2 - Ordering Coil Hardware

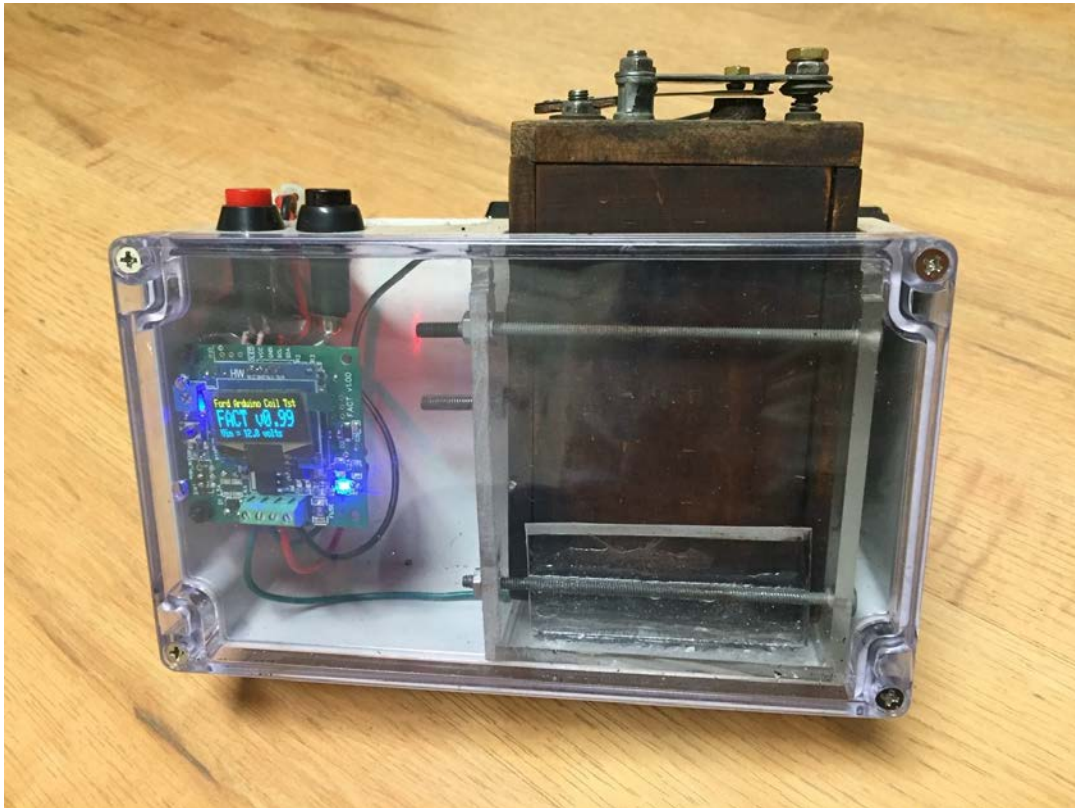
(Also see [reference 3.](#)) (Prices from summer 2019, use as a reference.)

Image	Description	Price/Quantity	Purpose
	Brass Hex Nut, 10-32 Thread Size, 3/8" nut https://www.mcmaster.com/92671A195	\$8.72/100	Adjustment nut
	Brass Hex Nut, 10-32 Thread Size, 5/16" nut https://www.mcmaster.com/95130A160	\$9.78/100	Lock nut for above
	Machine Tool Plug Chamfer Tap for Through-Hole Threading, 12-32 Thread Size https://www.mcmaster.com/25705A57	\$29.80/each	Use with nuts above for 4 nuts on mounting studs
	#12-32 Jam Nut 0.312" (7.92mm) 5/16" Stainless Steel, Gold Plating 1-328690-2-ND	\$2,940.00/2000	For 4 nuts on mounting studs <small>*Note: These are rare to find</small>
	5007N Nut Set For Coils, Brass https://www.chaffinsgarage.com/catalog.pdf	\$1.50/one set	
	5 mm flat washer .043 thousands thick		
	Cadmium-Plated Steel Mil. Spec. Washer for Number 10 Screw Size, 0.365" OD, MS-27183-47 https://www.mcmaster.com/98032A466	\$2.40/100	Shim spacers on compressed wood
	Aluminum Unthreaded Spacer, 3/8" OD, 7/16" Long, for Number 12 Screw Size https://www.mcmaster.com/92510A278	\$1.15/each	Spacer for contacts
	Fiber washer for spring		
	spring		
	capacitor		
	Brass Pan Head Slotted Screws, 4-40 Thread Size, 3/16" Long https://www.mcmaster.com/92443A076	\$5.89/100	Cushen spring rivet replacement
	Brass Hex Nut, 4-40 Thread Size https://www.mcmaster.com/92671A005	\$4.65/100	Lock nut for screw above
	Extra-Long Life Machine Tool Tap, 4-40 Thread Size https://www.mcmaster.com/2568A33	\$13.10/each	Tap for above

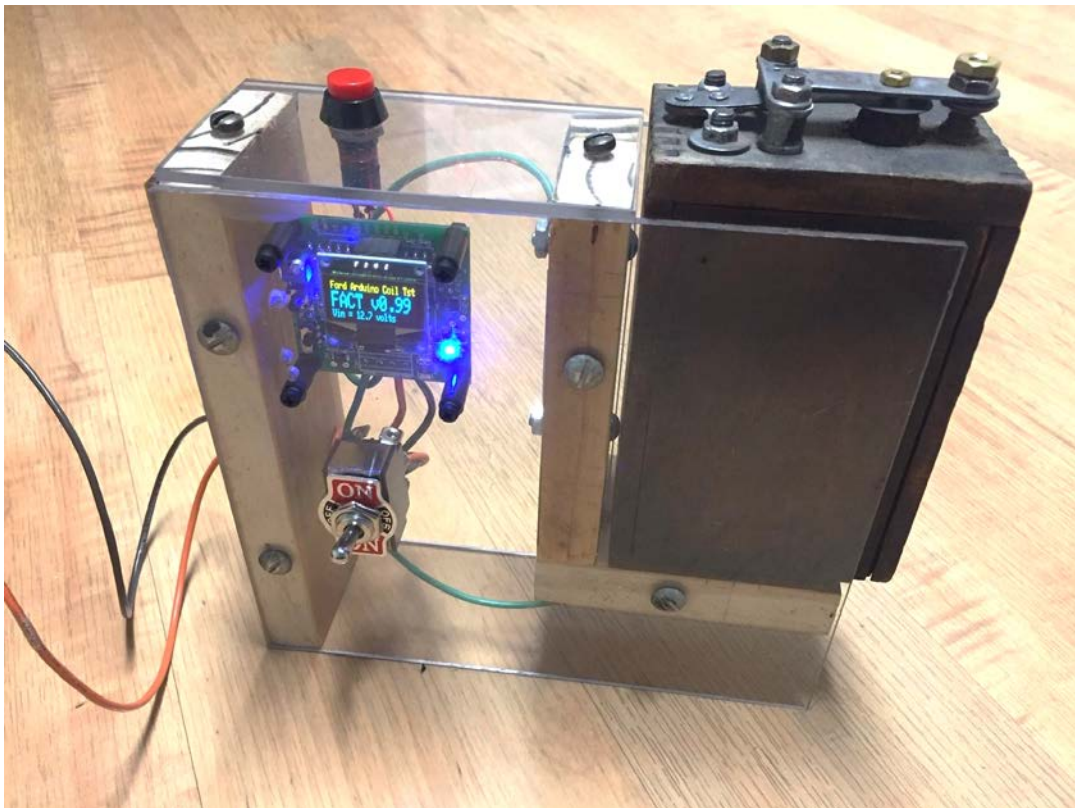
Appendix #3 - Example Test Fixtures

There are many options for building test fixtures. Here are two.

Premade Electronics Box



DIY Box



Appendix #4 - Basic Electrical Tests for Multiple Coils

Connections/ Ohm Readings

A-B: $\infty \Omega$ (w/points open)

A-C: 0Ω

A-E: 0.295Ω (w/points closed)

B-E: 0.295Ω

C-D: 3300Ω

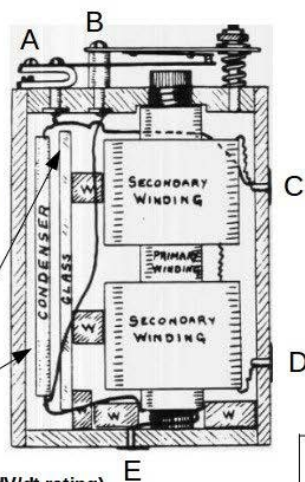
Note: Connections at A and B are sometimes reversed (more common on K-W coils).

Condenser

$0.40-0.45 \mu F$

replacement capacitor spec:

$0.47 \mu F$, $>400VDC$, $>600V/\mu sec$ (dV/dt rating)

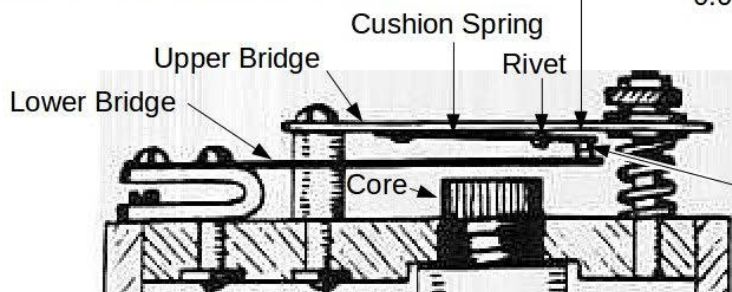


Problem Causes - Symptoms

- **Condenser Open** – heavy blue arc on points but no spark (A-B $\infty \Omega$ w/ points open)
- **Condenser Shorted** – no arc on points, no spark and irregular current draw (A-B 0Ω w/ points open)
- **Secondary Coil Open** – points vibrate and no spark (C-D $\infty \Omega$)
- **Secondary Coil Shorted** – points vibrate but irregular spark (C-D 0Ω)
- **Primary Coil Shorted** – points don't vibrate and irregular current draw (B-E 0Ω)
- **Primary Coil Open** – points don't vibrate, no current draw and points are clean/adjusted (B-E $\infty \Omega$)

Cushion Spring Gap:

(cushion spring touching rivet head with very light pressure, make all four coils the same gap)
 $0.003-0.005"$



Point Gap:

$1/32"$ or $0.029-0.031"$
(with lower bridge pulled down to core)

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(Figure above [drawn by John Carter.](#))

Test results:

Coil #	A-B (w/Points open)	A-C	A-E (w/Points closed)	B-E	C-D	Point Gap	Cushion Gap	Condenser	Current Draw
Nominal	$\infty \Omega$	0Ω	0.3Ω	0.3Ω	3300Ω (Ford) 2100Ω (some KW)	$1/32"$	$0.005"$	$.47 \mu F$ If can't measure replace with new.	1.3 A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A
	Ω	Ω	Ω	Ω	Ω	"	"	μF	A

Appendix #5 - Specifications of Coil Unit

(see [Specifications of Coil Unit](#))

(1926) Accession 94, Box 171, Ford Archives

Turns

Primary

212 turns

*20 gauge wire with cotton wrapped insulation

Secondary

16,600 turns

*38 gauge wire of multiple layers insulated between layers by waxed paper

Ratio of windings 78 to 1

Resistance

DC resistance Primary .295 ohms

Secondary 3300 ohms Inductance (Some KW coils are 2100 ohms)

Inductance

Primary

.0033 henrys (secondary open)

.0006 henrys (secondary shorted)

Secondary

22 henrys (primary open)

11.3 henrys (primary shorted)

Impedance at 133 cycles (25 mph)

Primary

2.77 ohms (secondary open)

.580 ohms (secondary shorted)

Secondary

18.700 ohms (primary open)

9.960 ohms (primary shorted)

Capacitance

Capacitor .40 -.45 uF (Ford specified 3-4 uF)

Made of two pieces of tin-foil seven feet and 3 inches wide.to layers of glassine paper insulation between one layer on top and one layer on the bottom. (see [article](#) for more information.)

Appendix #6 - Miscellaneous Charts

Magneto Output (From Ford Service Manual page 140)

RPM	MILES PER HOUR		VOLTS	AMPERS	CYCLES PER SECOND
	Car	Truck			
200	5	2.63	.5	6.1	26.4
400	10	5.26	9.8	7.9	52.8
600	15	7.89	14.4	8.5	80.0
800	20	10.52	18.8	8.8	106.4
1000	25	13.15	22.8	8.9	146.4
1200	30	15.80	26.2	9.0	160.0

Crankshaft Travel Versus Ignition Coil Operation (From [More Ignition Timing](#))

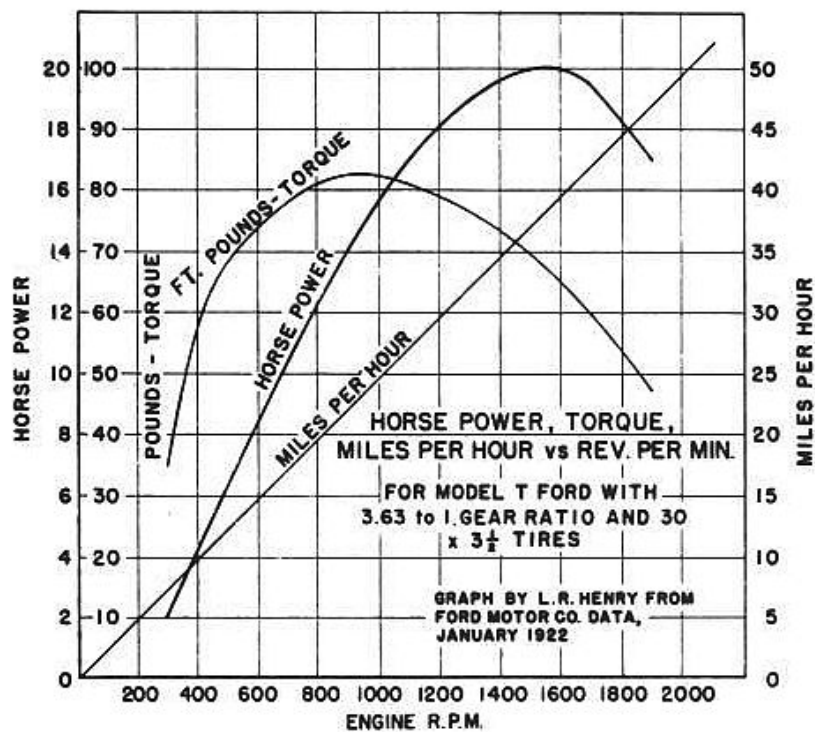
Crankshaft Travel Versus Ignition Coil Operation					
1	2	3	4	5	6
Engine RPM	Revolutions Per Second	Crankshaft Degrees Per Second	Crankshaft Degrees Per Millisecond	After Timer Contact, Degrees Crankshaft Travels Before Coil Fires on 6 Volts	After Timer Contact, Degrees Crankshaft Travels Before Coil Fires on 12 Volts
500	8.33	3000	3.0	10.8	5.4
600	10.00	3600	3.6	13.0	6.5
700	11.67	4200	4.2	15.1	7.6
800	13.33	4800	4.8	17.3	8.6
900	15.00	5400	5.4	19.4	9.7
1000	16.67	6000	6.0	21.6	10.8
1100	18.33	6600	6.6	23.8	11.9
1200	20.00	7200	7.2	25.9	13.0
1300	21.67	7800	7.8	28.1	14.0
1400	23.33	8400	8.4	30.2	15.1
1500	25.00	9000	9.0	32.4	16.2
1600	26.67	9600	9.6	34.6	17.3
1700	28.33	10200	10.2	36.7	18.4
1800	30.00	10800	10.8	38.9	19.4
2000	33.33	12000	12.0	43.2	21.6
2200	36.67	13200	13.2	47.5	23.8

Figure 3: Crankshaft Travel Versus Ignition Coil Operation
(Data collected by Ron Patterson)

Dwell & Magneto voltage

Note: The higher the magneto voltage the shorter Time-to-Fire this reduces the effect of dwell time differences from coil to coil.

RPM	MILES PER HOUR	MAG VOLTS	Crankshaft Degrees per Millisecond	Dwell for every .1 millisecond difference time to fire	Actual Dwell for every .1 millisecond
200	5	.5	1.2	.12	
400	10	9.8	2.4	.24	
600	15	14.4	3.6	.36	
800	20	18.8	4.8	.48	
1000	25	22.8	6	.6	
1200	30	26.2	7.2	.72	
1400	35	29?	8.4	.84	
1600	40	31?	9.6	.96	
1800	45	33?	10.8	1.08	
2000	50	35?	12	1.2	

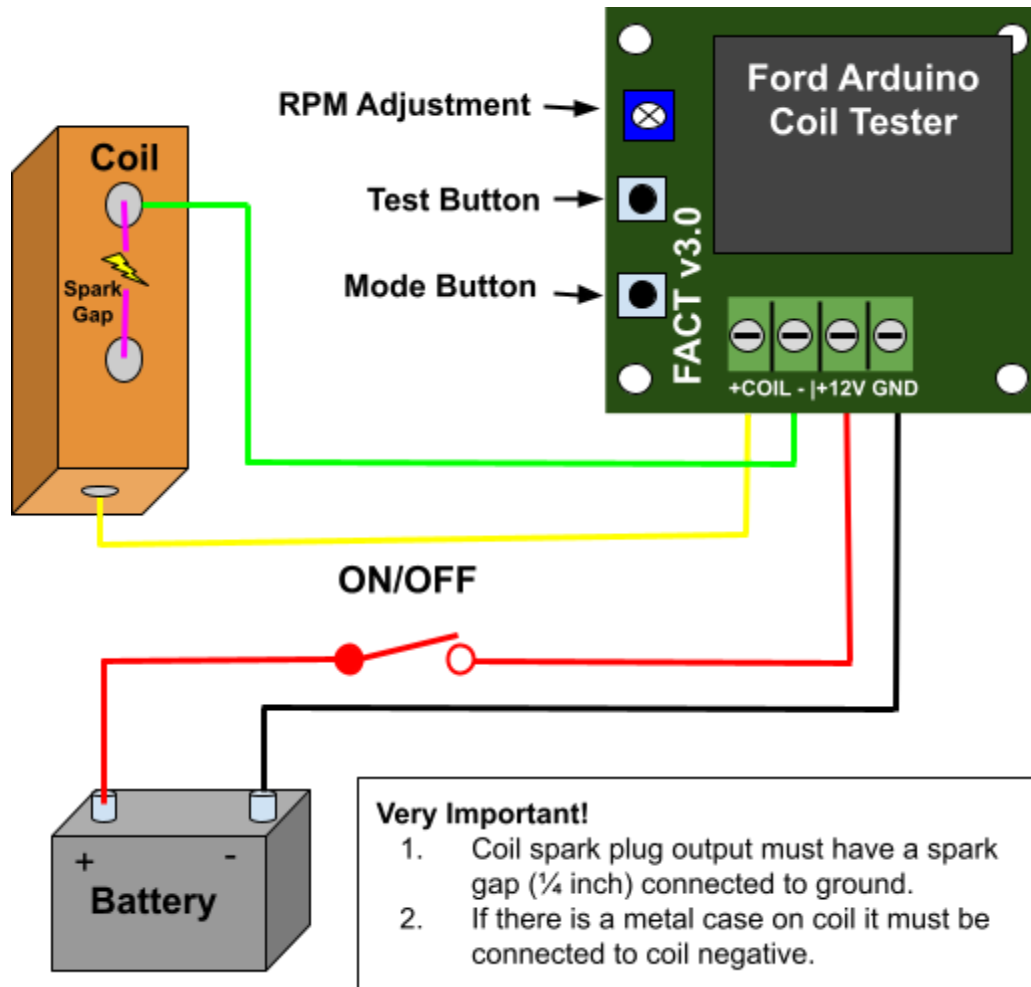


Additional Articles/References

1. Excellent article originally printed in *Vintage Ford The Ford Electrical System*
<https://www.nwvs.org/Technical/MTFCA/Articles/2102IgnitionSystem.pdf>
2. *The Model T Ignition Coil* by By Trent Boggess and Ronald Patterson. Very good history of the ignition coils.
<https://studylib.net/doc/8191195/the-model-t-ignition-coil>
3. Figure drawn by John Carter from:
<http://www.mtfca.com/discus/messages/599638/646227.html?1464833674>
4. Discussion on Cushion Spring Gap and how to adjust (.005" preferred, but can go up to .012" and most importantly all should be the same):
<http://www.mtfca.com/discus/messages/80257/98687.html?1247931406#POST174792>
5. Ordering coil hardware:
<http://www.mtfca.com/discus/messages/80257/94772.html?1250731519>
6. Another Model T Coil Cushion Spring Adjustment Tool:
http://www.pbase.com/jimthode/coil_current
7. ECCT Instruction Manual (Lots of good info about coil adjustments) by Mictel LLC
<https://img1.wsimg.com/blobby/go/f7680751-19cd-4e19-be37-bbb767146cbd/downloads/ECCT%20Instructions%20V12.pdf?ver=1606881770749>
8. Videos on Coil rebuilding (Part 1, click on next to see all three videos.)
https://www.youtube.com/watch?v=uhaXW3jaG0Q&list=PLYG_IhIwKyL1_nmd6sCkGZBwglKpRWA3
9. *More on Model T Ford Spark Timing*, by Ron Patterson
<http://www.mtfca.com/encyclo/ignition2.pdf>
10. *The Double Spark Doctrine Paradox*, By Mike Kossor
<https://img1.wsimg.com/blobby/go/f7680751-19cd-4e19-be37-bbb767146cbd/downloads/The%20Double%20Spark%20Doctrine%20Paradox%20V5.pdf?ver=1606881770750>
11. *The Model T Ignition Coil Part I: The Ford/K-W Ignition Company Story*, By Trent Boggess and Ronald Patterson
http://docs.wixstatic.com/ugd/3a96dc_cf55a51ac76a42ab9087dd905c5d4e55.pdf
12. *The Model T Ignition Coil* by Trent E. Boggess & Ronald Patterson
Vital details primary (212 turns), secondary (16,600 turns), Buzz 200 times/second
<http://www.mtfca.com/coils/Coils.htm>
13. *Model T Service Manual* by Ford
<http://www.cimorelli.com/mtdl/servicemanual/1925smcolor.pdf>
14. *MTFCA Online Encyclopedia*
https://www.mtfca.com/model_t_encyclopedia/cd/

Testing with the Ford Arduino Coil Tester (FACT)

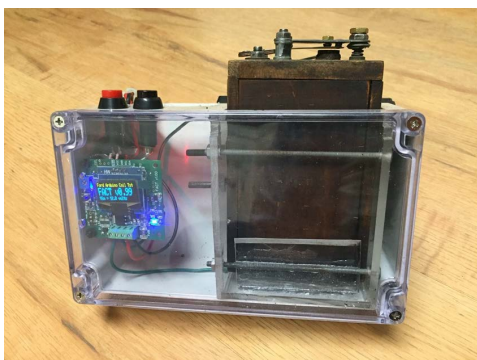
Please refer to the following pictorial diagram for connecting the Ford Arduino Coil Tester:



Simply put, the FACT coil tester is an oscilloscope that graphically displays the time to fire and current consumed by the coil. The FACT does this by sending an electronic pulse for 50 ms.

Example Test Fixtures

There are many options for building test fixtures. Here are two.


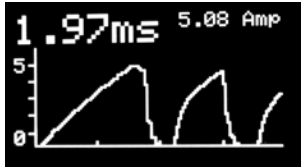

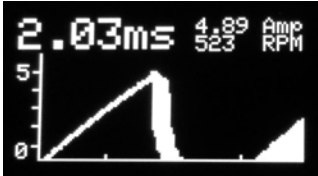


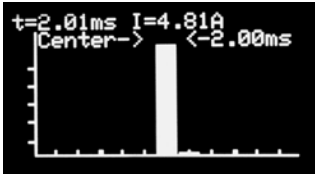

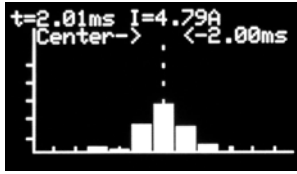








Premade Electronics Box



DIY Box

FACT Testing Cheat Sheet

SINGLE FIRE TEST			
	Good waveform. Nice ramp with clean drop off.	Double Spark caused by improper adjustment of cushion spring.	Bad Capacitor causes faulty waveform.
LIVE OSCILLOSCOPE			
	Good waveform Waveforms overlap with narrow lines and a new waveform is just starting on the far right.	Double Spark causes lots of overlapping waveforms after the initial ramp.	Bad waveform Lots of inconsistent overlapping waveforms.
BAR GRAPH TEST			
	Ideal It is desirable to have all the time-to-fire measurements in a single 0.1 ms column.	Okay If the coil is a bit erratic some of the measurements will fall in the adjacent columns.	Bad Very erratic measurements will lead to data in many different bars
MULTIFIRE TEST	 <p> t = Average time to fire in milliseconds. SD = Standard Deviation. The smaller the value the higher the precision, so a small value is desirable. Dwell = Degrees of dwell Max Current = Average of maximum currents measured. RPM=The speed may be adjusted using potentiometer. </p>		
CAPACITOR TEST- Graphical Analysis			
	Good waveform. Note that waveform traces the ideal waveform.	Points Closed. Points must be opened for testing. (Place a piece of paper in points for testing.)	Bad Capacitor causes faulty waveform.
CAPACITOR TEST- Detailed Analysis (Shown after Graphical Analysis.)			
	Good capacitor is in the prescribed range.		Bad Capacitor causes faulty waveform.

