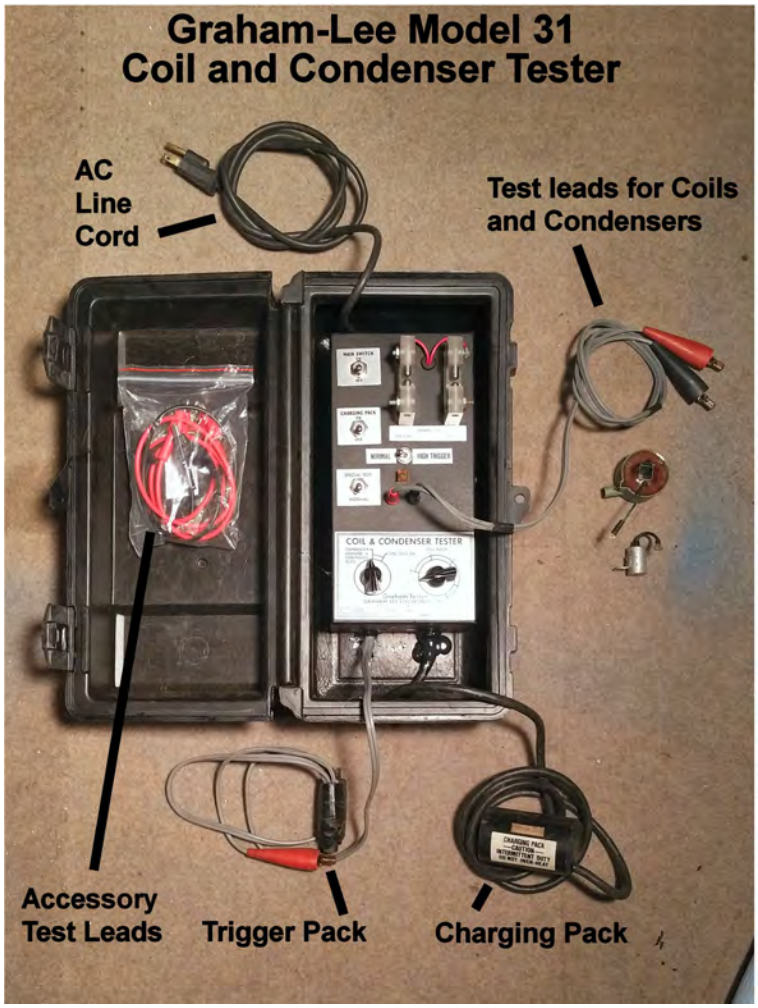
Troubleshooting the Graham-Lee Model 31 Coil/Condenser Tester

Troubleshooting_GL31.doc Rev. 1.1 W.Mohat 11Nov2018

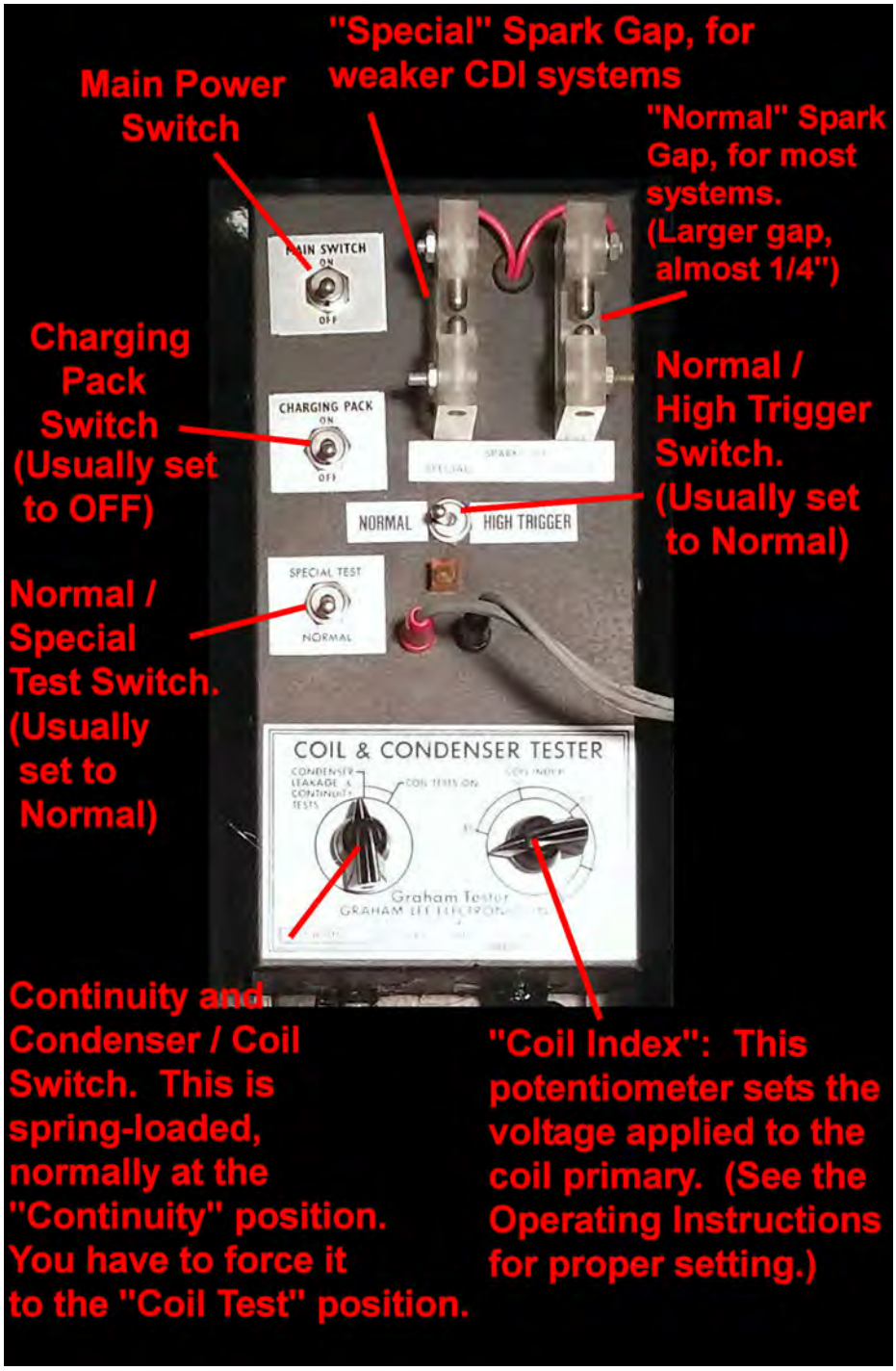
The Graham-Lee Model 31 looks like a basic, economy Coil / Condenser tester. It actually has more functionality than that. It includes a “charging pack”, to check alternators and charging systems for CDI ignitions. It also has a "trigger pack", to check newer-style magnetos with “trigger coils" instead of points, and many types of older ignition systems. To see all that this device can do, refer to the “Operating Instructions for All Model 31 Graham Coil and Condenser Testers” ..... (Filename: **Manual 31.pdf**)

The purpose of THIS document is NOT to show you how to use the Model 31 - the purpose of this document is to show you how to REPAIR your Model 31, should it fail or stop operating correctly in some way. And no, this is NOT an exhaustive troubleshooting document; its’ only a "Quick Reference" that is highly likely to get your unit running again very quickly.

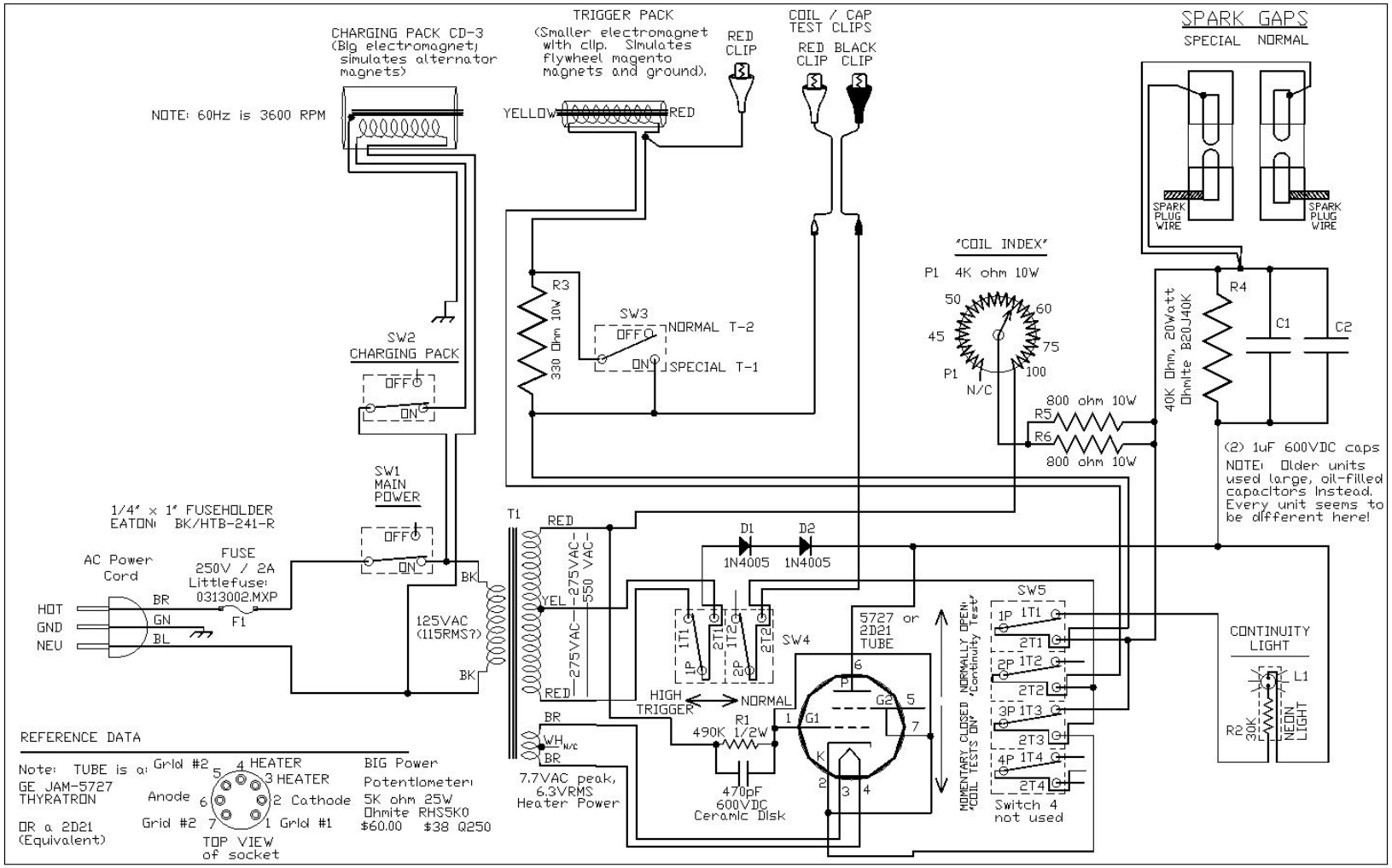
Let’s begin! The picture below shows the basic Model 31, and it’s key components:



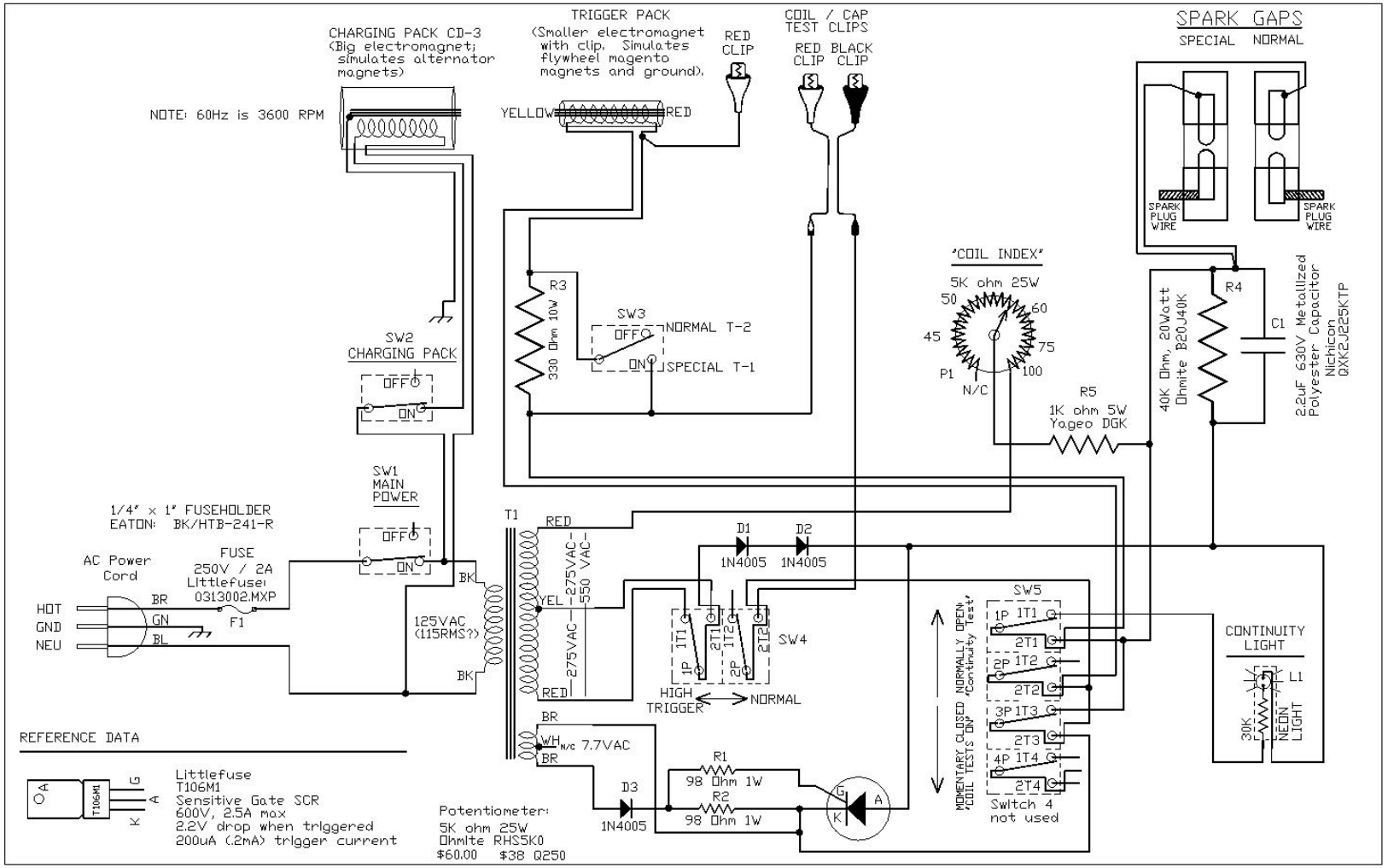
Here's a closer look at the Model 31's controls, and what they are for:



Now, there never were any schematics published for the Model 31. And, there were actually several models. Versions built before 1990 were built with vacuum tubes, and versions built during the early 1990s were built with SCRs. Schematics for each version can be seen on the next two pages. (For full 11" x 17" versions, see "Model31_TUBE_Schematic.pdf", and "Model31_SCR_Schematic.pdf")



GrahamLee31SchematicTUBE.dwg



GrahamLee31SchematicSCR.dwg

THEORY OF OPERATION, and TROUBLESHOOTING NOTES

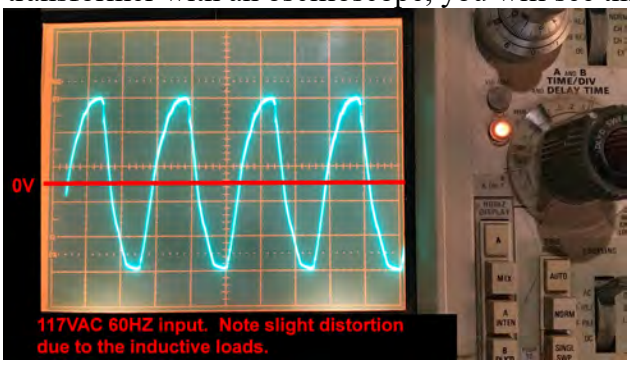
Look at the SCR version of the schematic. (Actually, the device used is a “Sensitive Gate Silicon Controlled Rectifier"..) Right at the line cord, there are two connections. One is through switch SW2 to the “Charging Pack"....which is just a large electromagnet.

TROUBLESHOOTING NOTE: To start, the Charging Pack is just a coil of wire. However, it’s NOT a very good electromagnet, as it tends to overheat rather quickly. It’s intended to only be used for about 5 minutes at a time. If you exceed this limit, there’s a thermal switch inside the coil that will "open up", to protect the charging coil from melting. This switch is supposed to automatically reset when the coil cools back down….but it CAN fail in the “open” position....and if it does, the Charging Pack will appear “dead". To test the charging pack, close SW1 (main power switch), and MOMENTARILY close SW2 to turn on the Charging Pack….then hold the Charging Pack near some paper clips (or any other steel objects). You should be able to pick up small steel objects with this coil.

OK…on we go. The other main connection is to Transformer T1. This has several windings on it. The main power input winding expects to see 120VAC, 60 Hz. On the secondary side, we have TWO “secondary" windings. The first one is a center-tapped secondary, with 550 VAC across the mains, and 275VAC from the center tap to either of the mains. (The Normal / High Trigger switch selects which of these voltages you will start with.) The high-power (15 watt) potentiometer P1 then scales the selected raw voltage down, to whatever test level is desired.

The OTHER “secondary" winding is 7.7VAC peak (about 6.3VRMS, used to power the “heater” on the vacuum tube, in the tube version of the Model 31.) On the TRIAC version, this low-voltage secondary winding is used to trigger the TRIAC (again, actually just a SCR.)

If you look at the transformer with an oscilloscope, you will see this:



You will see either 550VAC or 275VAC, depending on which pair of wires you are measuring across.

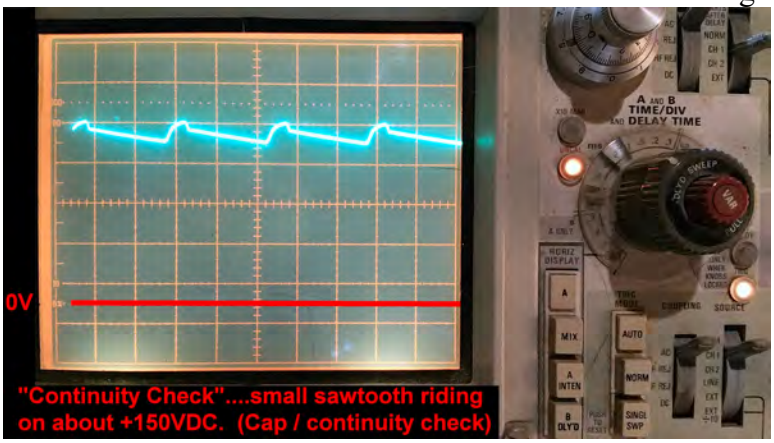
SHOCK HAZARD WARNING: The chassis of the Model 31 is connected to the ground wire in the 3-wire power plug. DO NOT remove this ground lead, and NEVER operate the Model 31 on any outlet that is not a 3-wire GROUNDED outlet. The voltages used inside this device CAN BE LETHAL…..please make no mistake about this. With the chassis properly grounded, it will protect your life if something inside the box “shorts out".

In spite of this, the “banana jacks" and the clip leads you plug into them have VERY HIGH, VERY HAZARDOUS voltages across them when the switch SW5 is in the “COIL” test position. BE VERY CAREFUL using this device, and MAKE SURE you are not touching ANY exposed wires when operating the Model 31. The life you save might be your own.

In addition…....looking at the schematic, you’ll see that NOTHING is "grounded" on the secondary side of transformer T1…..so everything is “floating”. This makes it difficult to take measurements, because there IS NO “GROUND" to connect your oscilloscope to. This means you will have to "float" your scope (or voltmeter), and measure ACROSS specific test points in the circuit. Again, this leaves your oscilloscope ungrounded……so.....use caution, as you normally should when measuring hazardous voltages with ungrounded test equipment.

OK, back to the circuit. Right after switch SW4 selects either the high (550V) or the low (275V) range, there are two diodes in a row…D1 and D2. These are used to half-wave rectify the incoming voltage. The large capacitors C1 and C2 hold this voltage up, and this raw voltage (with a lot of “ripple" on it) is applied right across the two banana jacks, and connects to the RED and BLACK alligator test leads.

TROUBLESHOOTING NOTE: At this point, connect a KNOWN GOOD CONDENSER across the red and black test leads. Then, turn on the Main Power switch, and measure across the Red to Black leads. You should see the following:



This will be about 150VAC, with a lot of ripple on it. If this is what you see, diodes D1 and D2 are good.

Now, this specific setup is EXACTLY what you use to test condensers. When you first turn the power switch on, this “150VDC with a lot of ripple” is applied to the capacitor, **through** the neon "Continuity" light. So, when the Main Power switch is first closed, you will get a bright flash on the Neon light as the capacitor charges up. It should then cut back to “flashing” the neon light, at a shorter and shorter interval**. IF the condenser is bad, the 150VDC will break down the capacitor, and the Neon light will stay ON, indicating that the condenser has failed.**

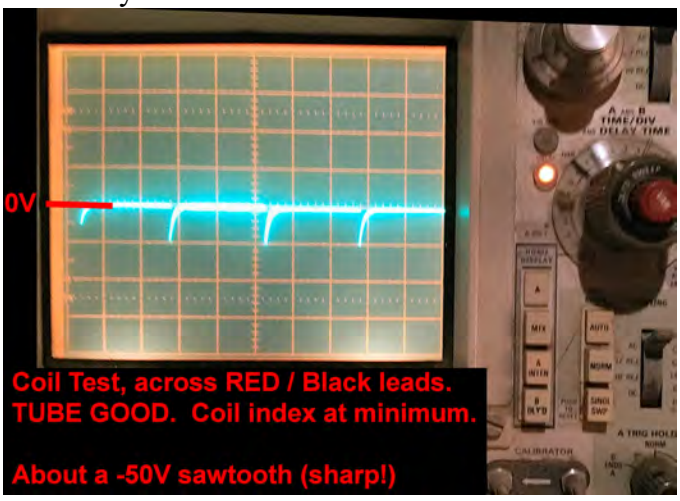
When you turn the Main Power switch back off, you will see the Neon light flash brightly again, (just once), as the condenser is discharged through the neon light.

A picture is worth 1,000 words, and a video is worth 1,000 pictures….so to see exactly what this should look like, go to YouTube on the Internet, and see the following video:
See:
https://www.youtube.com/watch?v=k_WvdjRgjME

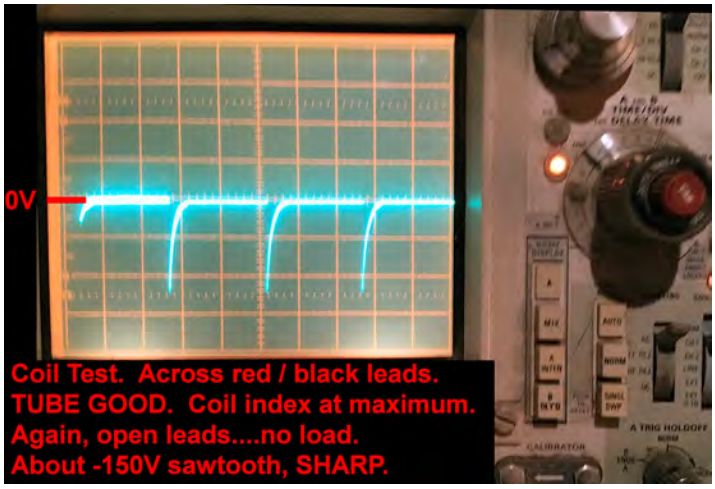
By the way, if you connect a coil to these alligator leads instead of a condenser, then turn on the Main Power, you should see the Neon light stay ON at full brightness, if the windings in the coil have continuity. So, this is a cheap “continuity" checker as well.

Testing COILS!! At this point, things start to get interesting. Up until now, the Tube (or SCR in the newer models) hasn’t been doing anything. However, connect a coil to the alligator leads, turn on the Mains Power, and then move switch SW5 to the “Coil Test" position, and suddenly things change drastically.

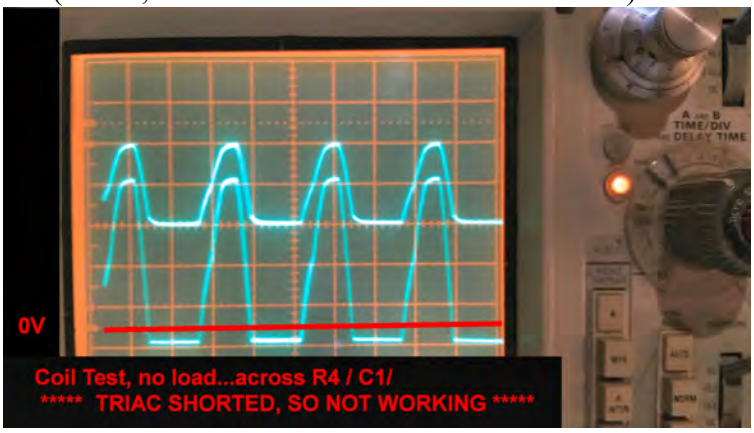
Switch SW5 is a wafer switch, set up as a 4 pole / double through switch. When you rotate this switch to the “Coil Test" position, this changes the circuit arrangement rather dramatically inside the Model 31. The Tube (or SCR) is now “active"....and what it does is rather interesting. If you connect your oscilloscope across the RED and BLACK test leads (with no coil connected), then rotate SW5 to the “Coil Test” position, with P1 set to minimum (45), this is what you will see:



If you crank up P1 full clockwise, the amplitude of this “sawtooth” waveform will increase to about a 150V “sawtooth”. See below for details:



Whether you have the old Tube or SCR version makes no difference, this is what you should see. If you do NOT see this waveform, the TUBE is DEAD. If you see something like this (below, the BOTTOM of the two waveforms) - the SCR is shorted:



TROUBLESHOOTING NOTE: MOST of the tubes you see will be dead. They are over 20 years old, and if you are trying to repair a non-functional Tube unit, the tube is most likely dead. The tubes are either type 5727, or 2D21…...these are Thyristors, a gas-filled tube that acts like a modern Silicon Controlled Rectifier. Fortunately, you can usually find these tubes on e-bay for about $10….but half of what you buy will be dead also. So, let the buyer beware, as they say. Trust, but VERIFY.

If you do NOT see the “sawtooth” waveform, replace the tube (or SCR). Once you do see the correct “sawtooth”, then your unit is likely completely functional.

The only other high-failure rate part is the neon light….they tend to leak, and go "dead". If none of the "continuity” or "condenser" tests cause the light to light up, then the neon light has failed. You can replace this with just about any 120VAC neon “panel light" from DigiKey (look for one that has the included resistor, but does NOT have an

included diode inside of it!!!) Once the tube (or SCR) and Neon lights are running, it's likely your Model 31 is ready to go.

TROUBLESHOOTING NOTE: The only other high-failure situation in Model 31s are the wires themselves. Some of the wires used to manufacture the Model 31s were junk, and after 20 or 30 (or more) years, these insulation on these wires just crack and fall off. Go over your unit carefully, and replace any and all cracked or stiff insulation. Wire-tie the wires inside the Model 31 to stabilize them after you have replaced bad wires. Be diligent about this, as this will GREATLY increase the lifetime of your unit!

COIL TESTING: Assuming you see the correct "sawtooth" waveform, turn the power switch off. Then, test a coil with the Model 31. The correct setup is as follows:

With a known good spark coil connects as shown above, set the “Coil Index” to about “55” on the dial. Turn on the Mains power, and rotate switch SW5 to the “Coil Test” position for a few seconds. You SHOULD see and hear a hot spark across the spark gap!

TROUBLESHOOTING NOTE: If you have your scope connected across the RED and BLACK test leads (along with the coil), you should see the following waveform:

It's a LOT easier to test the TUBE / SCR without that coil messing up the signal!

And, just like before…..if you want to see a video of this "Coil Test", you can go up to YouTube and view this video:

See:
https://www.youtube.com/watch?v=hHPRwqOX7lo

If your Condenser and Coil tests pass, your Model 31 is now functioning properly. Again, refer to the official operators' manual from Graham-Lee, for details on how to run many other types of tests with this piece of test equipment.
See: "**Operating Instructions for All Model 31 Graham Coil and Condenser Testers**" ..... (Filename: **Manual 31.pdf**)

And, for large 11" x 17" full schematics, see the files:
"**Model31_SCR_Schematic.pdf**", and "**Model31_TUBE_Schematic.pdf**")

Errata and Misc. Notes:

1) In the schematics, you might note that the "Normal" spark gap is much bigger than the "Special" spark gap. At first glance, this seems backwards.....you would think that the "normal" gap is supposed to be set much smaller than the "Special" spark gap. **However, the "special" gap is for low-power CDI ignition system that don't have a lot of "oomph" to them, and can BARELY jump across a standard spark plug, even under the best of conditions.** Unfortunately, the Graham-Lee documentation does NOT ever mention what the correct "gaps" should be for these two different spark gaps. I think the "Special" should be about .035", and the "Normal" about .20". Yes, the older ignition systems were VERY HOT, compared to a lot of the modern junk you will find out there.
2) The 5727 (or 2D21) tubes are not all that hard to find on e-bay. However, finding GOOD ones is another story altogether. Many sellers will claim that they tested their tubes on "specially calibrated tube testers" (yadda, yadda, yadda)……but, my experience has been that HALF of the tubes I bought were dead on arrival. These tubes haven't been manufactured for 20 years, and old stock tends to leak. Still, they typically cost about $10....so, it's not a terribly big deal if you have to buy two of them, to get one that actually works. Having a tube checker, or even one known good tube, will allow you to make comparisons between a "unknown" unit you just bought, and a known good unit. If the tube you bought passes the "coil test", that's all you need to know.

3) The “Coil Test”....even with a COMPLETELY DEAD tube or SCR, will always have at least ONE arc across the spark gap. But, if the tube or SCR is dead, you won’t get a continuous stream of arcing (with a loud “zaaaapp!" sound). That’s your test criteria for passing!
4) OK, you might think the SCR version would be easier to support. However, the specific T106M1 SCR used in the original manufactured product was built by Littlefuse, and they have obsoleted this part. None of the vendors I could find had this item in stock. (They all had it listed, but had “0 on hand”, and no idea when they could get more. And that would be ….. NEVER .... since Littlefuse doesn't make them anymore.)

   However, I did find a “generic replacement T106M1” up on e-bay…..I think the markings on it look like “Teccor” manufactured them. But, they DID appear to work. I think these were about $5.50 each. God knows if any others will be available.....so the TUBE version of the Graham-Lee Model 31 testers MIGHT be easier to support over time, as there are many places that still sell old tubes.
5) Neon lamps tend to leak gas and fail over time as well. If you don’t get any light on your neon lamp during a continuity test or condenser test, the light must be replaced. ANY panel-mount 120VAC neon lamp (with built-in resistor) will work. But, make sure it doesn’t include a DIODE in there as well.

   The specific neon lights I used for repairs were from DigiKey, their part number was **6010M1-ND…...a "INDICATOR NEON RED PANEL MNT".** This unit was brighter than the original lights in units that still work. Again, NEW Neon lamps will always be brighter than older ones.

6) WIRES: As I mentioned in this document, old insulation tends to dry out, harden and crack. About half of the units I worked on had bare wires, and lots of cracked insulation. (Always on the wires going to the Trigger Coil, for some reason.) These must be replaced.

   Now be careful here……most “twinlead" wire you find at your local hardware store, Home Depot or Loews, will ACTUALLY be for “low voltage lighting” (landscape wiring)…..or at best, it will only be rated for 120VAC. Unfortunately for us, the Model 31 produces voltages up to 550VAC…..(although it doesn't send ALL of that voltage outside the box. You still can get over 250VAC on these wires, though). **SO…...make sure the wires you buy are rated for 600VAC. (I found a supply at a local "mom and pop" hardware store.**) You might have to look around a bit as well. DO NOT use wire with lower insulation value. I don’t know what the liability is that you would face if someone gets electrocuted using a box you repaired, but overdoing it on the insulation on your replacement wires is a good investment, no matter how you look at it.

********** END OF DOCUMENT **********