SAVING THE LUCAS RB106.

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Background:

This article examines and explains how to slightly modify a standard RB106 so it will be reliable and be a good charging and voltage regulator system for the car.

The modifications outlined here are simple and reversible and can be done to an RB106 regulator used in either positive or negative ground situations. The idea is to essentially keep the regulator system original. Also this modification includes only the disconnection of one link strap to the field coil, which can easily be re-connected later to return the unit to original condition if that was ever required.

If we return to the Lucas compensated charging scheme for the RB106 for analysis:

I test these units in my test bed system shown in Figure 1 below where the photo shows one of my electronic regulators under test:

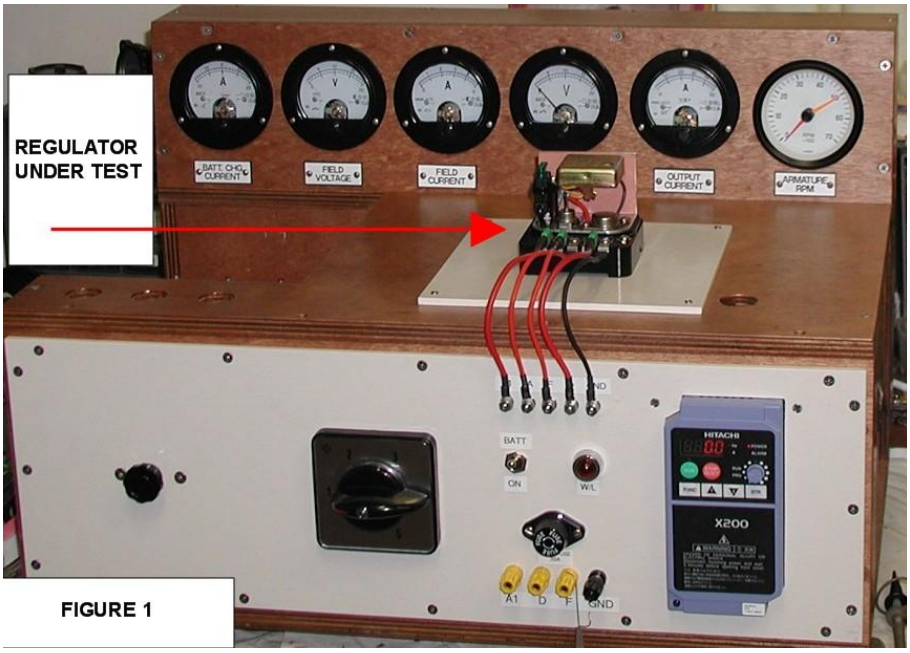

FIGURE 1

This test unit contains a lead acid battery and a C40 dynamo driven by a speed controlled three phase motor and an assortment of dummy loads and meters including an rpm meter for the dynamo armature. External digital meters and temperature probes are also used.

For an original new old stock LUCAS RB106 tested I have found that the equation which defines the output voltage with respect to current loading at the A and A1 terminal @ 25 degrees C is close to:

$$Vout = Vset - (0.13A1 + 0.08A)$$

Vset is the voltage, measured on the D connection set by adjustment on the regulator with no output current (paper insulator placed in the cut-in contact) so that A1 terminal current and the A terminal current are zero. This is set to 16V @ 25 degrees C and an engine rpm of 3000. (2500 is adequate).

A in the equation is the charge current via the A terminal to the battery and A1 is the external load current via the A1 terminal to loads like the headlamps. Vout is the voltage on the A1 or A terminal.

The A and A1 terminals of the RB106 are connected together by the 1 turn loop which has a very low DC resistance of less than a milli-Ohm so they can be regarded from a voltage perspective as being shorted together so the terminals assume the same voltage.

For example with Vset on the regulator adjusted to 16V and then say 5 amps total battery charge current and 10 amps external load current, the output voltage Vout, on the A or A1 terminal would be reduced below 16 volts to:

$$Vout = 16 - (0.13 \times 10 + 0.08 \times 5) = 14.3 \text{ volts.}$$

Also for example, at a full load of say 21 amps via A1 and 1 amp charging current via A, the output voltage is close to 13.2 volts.

Therefore over the range of loads to 22 amps there is close to a 2.8 volt shift in the regulator’s output voltage, unlike the alternator system where the voltage is a stable value.

On consulting the manual, the regulator’s output voltage should have a negative temperature coefficient of 0.01 volts per degree C. This is done to match the increasing internal resistance of the lead acid battery with decreasing temperature.

The regulator’s output voltage therefore increases on cooler days and decreases on hotter days. This temperature compensation is believed to be derived from the special metallurgy of the return springs on the voltage regulator contact arm.

In general then, we can write the **“Equation for the RB106”** to include this feature:

$$Vout = 16.25 - (0.01T + 0.13A1 + 0.08A)$$

T is the temperature in degrees C. For example at 25 degrees C and zero A and A1 current (regulator off load) the output voltage equals 16V which is the correct setting. Then say at 40 degrees C ambient temperature Vout off load will be 16.25 – 0.01 x 40 = 15.85 volts. This agrees with the manual. It is an interesting point to note that a “true” electronic facsimile for the RB106 would have to conform to the above equation.

Practical Setting of the regulator's output voltage:

Follow the instructions in the TR4 manual (Autobook 778 by Kenneth Ball). This involves setting the off load output voltage, depending on the temperature. This is done by measuring the voltage on the D terminal and insulating the cut-in contacts. For example at 25 degrees C an off load output voltage of 16 V is satisfactory.

Many things are good about the LUCAS RB106:

While I have levelled some criticism at the RB106 in the past for certain of its features, there is no mistaking the fact that it is a triumph of electromagnetic engineering from days when the designers didn't have the luxury of modern semiconductors and they had to be very creative to make do with what they did have. In a sense, the RB106 is a downright cool device despite the problems.

Current sensing using the low resistance series coils is clever as it utilises the magnetic field generated by the current. Modern high efficiency amp meters do this too, albeit with a Hall Effect device to detect the field. The ammeter in the TR4 is also an example of utilising the magnetic field generated by current in a low resistance loop of wire to deflect a pointer.

The cut-out relay is a masterpiece. It is very reliable and easy to set. Follow the TR4 manual's instructions (Autobook 778 by Kenneth Ball), they are very clear. The cut-in should occur at 13V or close to that value. This corresponds to a dynamo armature rpm of close to 1400. Due to the pulley sizes in the car the engine rpm is lower than this. The relay will cut-out around 12.5 volts at that setting.

The cut-out system is much more efficient than any electronic (rectifier) counterpart. For example the power consumed by the cutout shunt coil is a mere 2 watts and at 22 amps current the series coil on it another 2.5 to 3 watts maximum. Most of the time the overall power loss is 4 watts or less. The contact losses are very small.

The most efficient Schottky rectifier I could find as a cut-out substitute (a 180 amp rated device) drops around 0.37V at 22 amps and dissipates around 8 watts. A standard silicon power rectifier (SSR) drops around 0.75 to 0.8 volts and the dissipation is severe at over 16 watts. If these diodes are housed inside the RB106 case the temperature can rise at full output current to around 65 degrees for the Schottky type and 80 degrees for the SSR at 25 degrees ambient temperature and potentially increase 20 degrees or more above those values in an engine compartment.

The electromechanical cut-out beats the rectifier in this application.

Also the cut-out/in system does hardly any mechanical work, only cutting in on starting car when the dynamo's armature speed is around 1400 rpm (engine around 900 rpm) and not cutting out unless the engine rpm is much below that value.

The compensation system and basic RB106 function, as defined by the equation, would be tolerable if the RB106 was reliable and not erratic. The problem in the RB106 is the main regulator contact opening and closing around the 30 times per second mark, and the arcing that occurs between the points surface fouls the points, much like they do in a standard ignition system. This is because the field coil, like an ignition coil, is an inductive load. Contact arcing is substantially reduced by a damper diode, such as a 6A10 or a 1N5822 diode, placed across the field coil terminals. Diodes work much better than the 60 to 70 Ohm wire wound resistor used in the unit, which allows the voltage to climb to over 80 to 100 volts negative when the contact opens. The diode clamps it to around –0.7 volts and less for the 1N5822 diode. However the contact still has to carry the full field coil current, which can be as high as 2.5 amps.

There is a very good method to help and save the RB106. This is easily done by adding 3 simple components to the RB106 unit. One of these is the damper diode cited above. The following diagram shows the original RB106 with the added parts, one diode and one resistor and one transistor. The transistor acts as a current amplifier and isolates the regulator contact from the inductive load of the field coil and reduces the contact's electrical current by a factor of 50 to100. This eliminates fouling of the contact and keeps the contact in immaculate order.

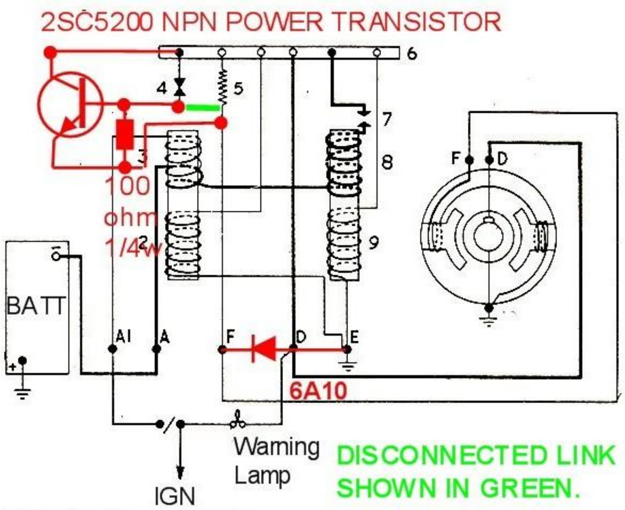

FIGURE 2.

Mechanical execution of this modification is very simple and is done as shown in the photos and instructions below. The first step is to mark out and drill two fine holes (1.2mm diameter) 11mm apart in the metal strap. This is the field coil connection, see Figure 3.

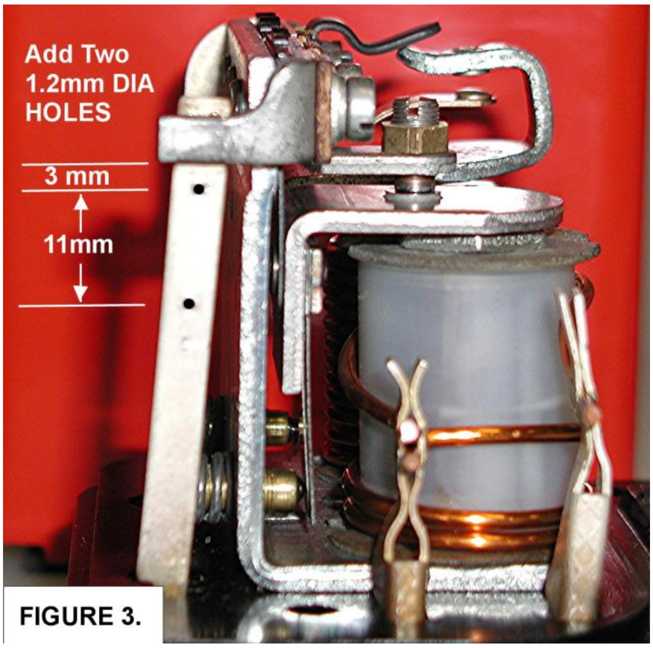

FIGURE 3.

The next step is to use a fine saw, such as a junior saw, to cut the strap between the holes, and file the burs from the cut edges with a fine file. See Figure 4.

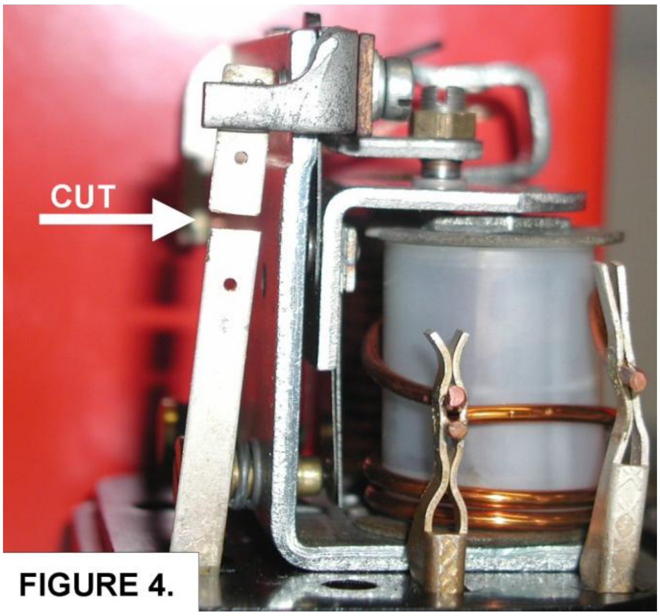

FIGURE 4.

This saw cut corresponds to the disconnected green link in figure 2. This concludes the structural modifications to the RB106. The change is reversible as this cut arm can be linked back together with a link wire and solder if ever needed.

Figure 5 shows the type of transistor to be used. In this case the Toshiba 2SC5200. Image label 1 shows the top view, image 2 the rear view and image 3 shows the central collector connection bent over and soldered onto a lug:

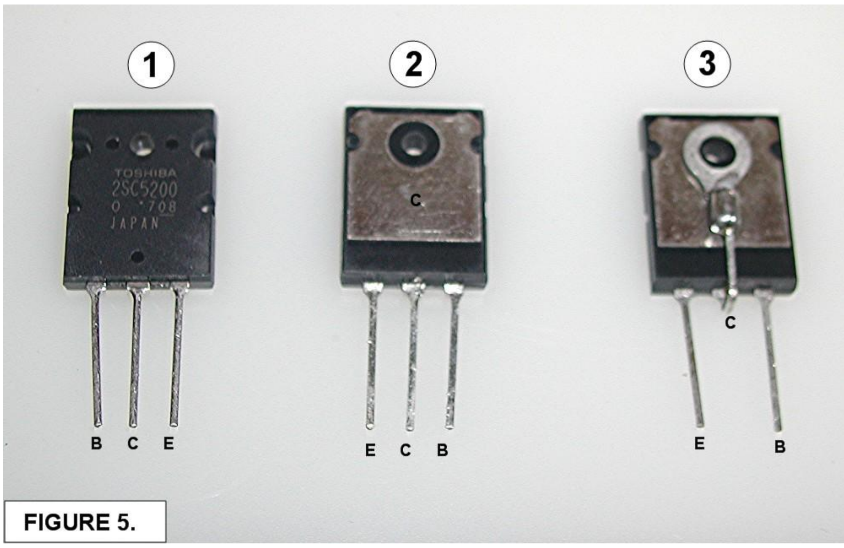

FIGURE 5.

The next step is to cut out a small rectangle of standard fiberglass PCB material and put in a set of matching 1.2 mm holes which are 11 mm apart. The central part of the copper track can be removed with a small file. This gives physical stiffness back to the cut area as will be seen. See Figure 6:

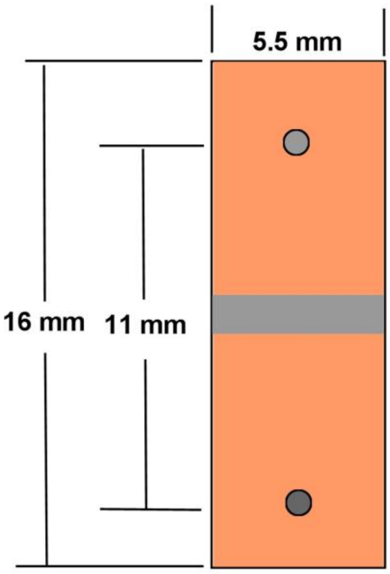

FIGURE 6.

The transistor is now screwed to the metal regulator structure as shown. There is a useful existing hole, central on the metal plate and 17mm from the top surface in some units. If your unit doesn't have the hole it will need to be drilled with a 3mm drill. Use a 3 mm diameter 15 mm long screw with an internal star washer under its head to stop it rotating when the nut is tightened and use a spring washer a flat washer under the nut. No insulators are needed. The transistor's collector connection is connected to the regulator body (the D connection) by the screw and lug assembly. The transistor's base and emitter wires pass through the holes in the cut strap. The PCB rectangle is placed over that. Both sides (the PCB track) and the brass strap side are soldered. Also the 100 ohm 1/4w watt resistor is connected across the transistor's base and emitter wires as shown. This ensures the transistor always turns off well when the contact opens. See Figure 7,8 & Figure 9.

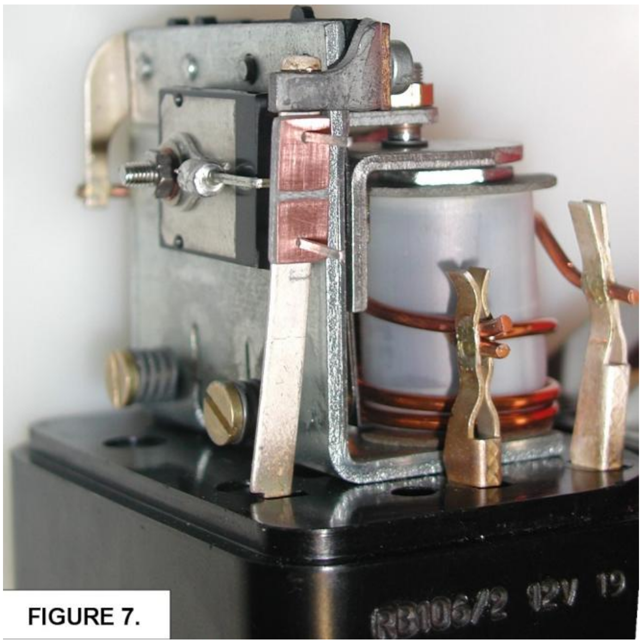

FIGURE 7.

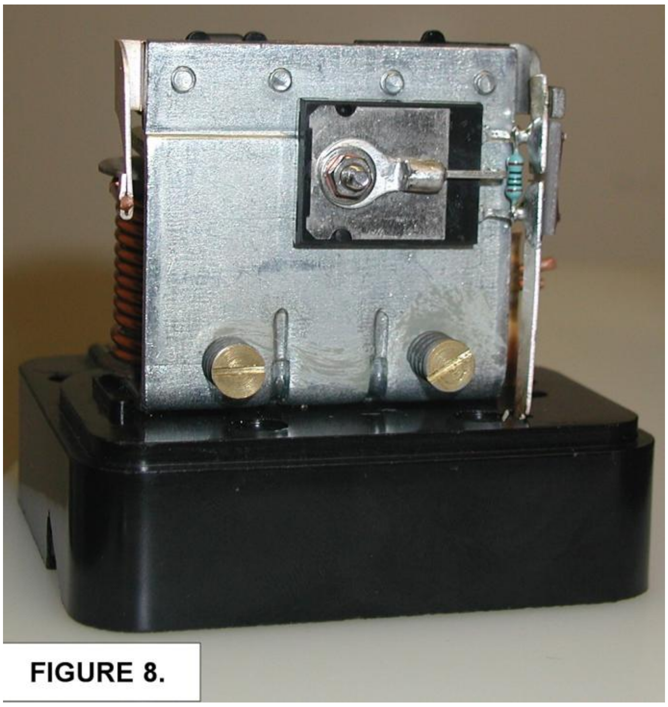

FIGURE 8.

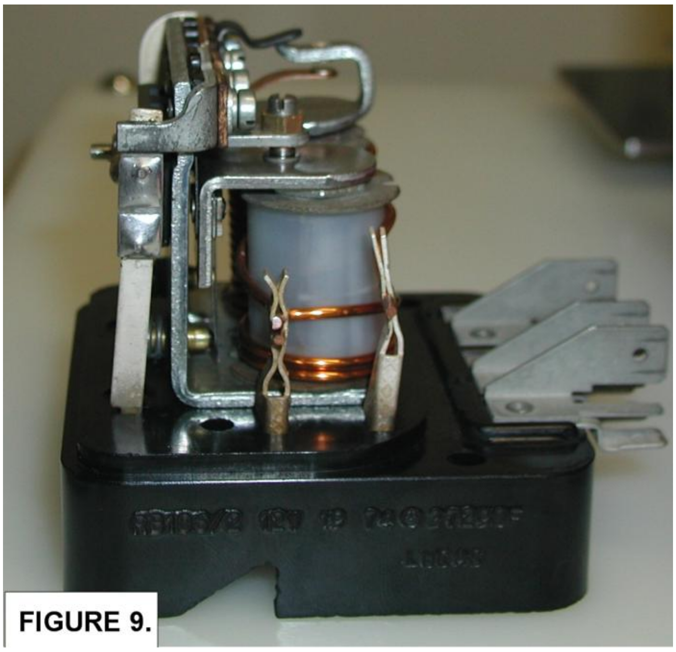

FIGURE 9.

Figure 10 shows the base of the unit which is unmodified except for the addition of the diode which is essential. Clean all surface oxides off the rivet before soldering the diode leg in there. The original 70 ohm resistor can be left as shown in situ. It performs no useful function in this transistor assisted design and it dissipates a little heat, so if you like you can remove it by bending open the clips, or simply leave it there for originality sake.

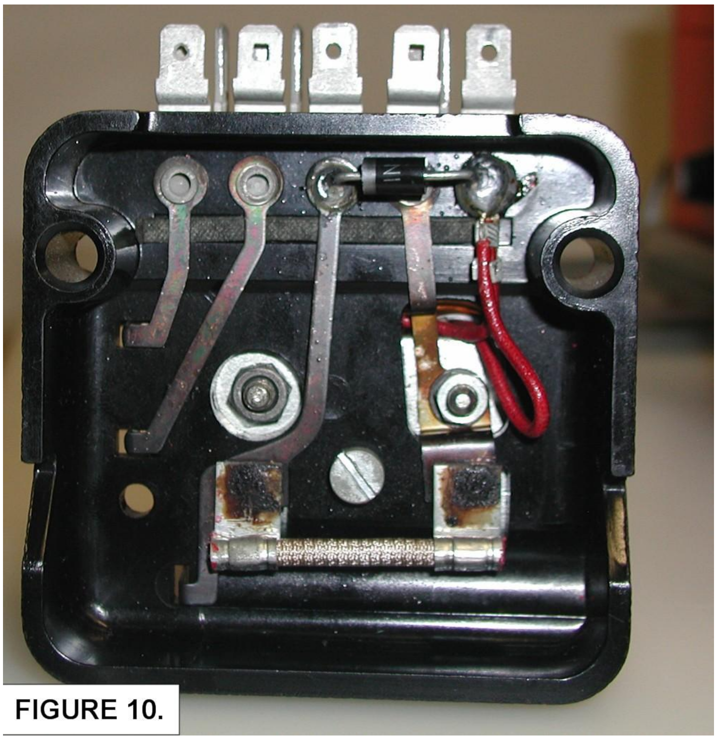

FIGURE 10.

The configuration shown here is for negative earth. To make a positive earth version simply reverse the direction of the diode and use the complimentary PNP transistor which is the Toshiba 2SA1943.

Both the 2SC5200 npn used in this design or the 2SA1943 pnp are great rugged power transistors and are easy to get on Ebay. They have a case configuration making them easy to adapt to the RB106. Due to the configuration of their pin outs they are mounted upside down to the conventional method, but it does not matter here as the maximum power dissipation is low at around 2 watts and they are a very hefty device. In this setup they are used as an emitter follower or current amplifier. For example if the transistor has a current gain of 100, which my 2SC5200 specimen has, when the emitter current to the field coil is 2 amps, the current via the voltage regulator contact in the base circuit is only around 0.02 amps. A small amount of current via a contact is thought to keep it clean.

Don’t forget to clean the regulator’s contacts as suggested in the manual, especially if the regulator has been in storage as they can get a glassy oxide like insulating layer on them or be blackened / burnt from previous use. It is good to start with a fresh Lucas regulator unit.

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