Voltage Regulator Adjustment Guide
By A. Rhodes

This article is first draft of theory and operation of generators and Lucas voltage regulators. The generators on old English cars seem always to be marginal when driving at night with running and head lights on. Probably the best answer to this problem is exchanging the generator for a more modern (and higher output) alternator. The Vintage Triumph Register website has details about much of the nuts and bolts of an exchange. In addition, it has an article by Dan Masters about the theory and operation of alternators (www.vtr.com). I have borrowed heavily from Dan’s work when writing this article. I refer you to his wonderful diagrams used in his alternator article as they apply directly here too. Anything you find useful I owe to him, and all errors are of course my own.

Generator - Theory of Operation

In order to understand the theory and mechanics of mechanical voltage regulators, you must understand how a generator makes electricity. The basic principle is that moving a wire through a magnetic field induces electrical current flow in the wire. The faster you move the wire, the greater the voltage that is induced. A generator essentially moves a loop of wire through a magnetic field around and around. Through one half of a full revolution a positive voltage is created, in the second half a negative voltage is created. Since generators were created before semiconductors were readily available, there had to be a mechanical way to avoid making the wrong polarity voltage. This was readily answered by reversing the connection on the wire loop as it entered the negative phase. The commutator inside the generator performs this function.

The magnetic field could be created by permanent magnets within the generator, but they are expensive and bulky and heavy. Additionally, they cannot be modulated to maintain a constant output voltage. It is more effective, cheaper and lighter to use some loops of wire to do the same thing. Just as it is possible to create a current in a wire by moving it through a magnetic field, it is also possible to create a magnetic field by moving a current through a wire. In order to make the field stronger you can loop the wire back on itself many times. This way a small current can create a large magnetic field. This is an electromagnet. In a generator this electromagnet is called a “field coil”. It is a series of loops of wire (a coil) which creates the magnetic field.

Now we have a device that creates electrical pulses of the correct polarity. The voltage coming out is proportional to the speed of the turning of the generator, and the magnetic field strength of the field coil. As the engine RPMs increase, the voltage from the generator also rises. Unfortunately, the electrical systems in a car like a fixed voltage. If the voltage is too high the battery will overcharge and boil over, light bulbs will burn out and the coil will melt. There must be some way to control the voltage output.

Voltage Regulator - Theory of Operation

For the purpose of an automotive generator the use of a field coil makes it possible to control the voltage output. We can not easily control the speed of the generator since this is directly linked to the engine speed. We can control the current in the field coil. Increasing the electrical current in the field coil will make the magnetic field stronger. Decreasing the current will reduce the magnetic field. The voltage regulator performs this function. The voltage regulator also performs some associated functions. It cuts the generator out of the circuit when the voltage from the generator is less that the battery voltage. This prevents the battery current from running backwards through the generator, discharging the battery. There is also a mechanism to prevent too much current being drawn from the
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generator which might overheat or otherwise damage the generator. In some models of regulators there is one relay (called a "bobbin" in voltage regulators) for each of these functions. In the TR2-4 series, and other models as well, there are only two bobbins. One of the bobbins serves two functions in this case.

The first bobbin we will discuss is the simple "Cut-out relay". It should be more properly described as the "Cut-in" relay because it keeps the generator out of the charging circuit until it is generating sufficient voltage for the bobbin to close contacts cutting the generator into the charging circuit. It is set to cut-in at 12.7 to 13.3 volts. Once in the circuit it will stay in until the generator output actually drops well below battery voltage (11 to 8.5 volts). This may never happen even at a very low idle.

In the TR2-4 series the second bobbin provides two functions. The primary function is to regulate voltage by reducing generator output by reducing the current in the field coil. The secondary function is to prevent excessive current output from the generator, again by reducing output. There are two separate windings on the bobbin to provide these two functions. In three bobbin regulators the voltage and current regulators are separate but functionally identical to what is described here.

When the voltage is below a certain set point there is a direct connection of the field coil to battery (actually battery plus generator) voltage. This gives the maximum magnetic field strength possible and thereby allows the generator to produce the greatest voltage possible. When the voltage exceeds a set point, the bobbin opens a contact which puts a resistor in line with the field coil and reduces the current running through the coil. This reduces the magnetic field strength, and in turn reduces the generator output. The contact is opened and closed frequently so the electrical system essentially sees the average of the duration of high and low voltages.

In the TR2-4 two bobbin system, the current regulation is performed by a separate winding on the same bobbin as the voltage regulator. This winding carries the full current output of the generator. The wire is wound so that increasing current through the wire will tend to open the contacts and lower the current in the field coil.

Regulator Adjustment

The only adjustments that you can make to the regulator are the contact gaps and the set points. I will quote the Triumph workshop manual regarding the adjustments. Their description is concise and thorough. I will add my comments in italics where additional explanations may be in order.

The control box (regulator) contains two units - a voltage regulator and a cut-out. Although combined structurally, the regulator and cut-out are electrically separate. The voltage regulator relay (bobbin) can be identified as the coil with just a few turns of heavy gauge wire around it. The cut-out relay has anymore turns of the same heavy gauge wire.

The regulator is set to maintain the generator terminal voltage between close limits at all speeds above the regulating point, the field strength being controlled by the automatic insertion and withdrawal of a resistor in the generator field circuit.

Cleaning Contacts
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(i) Regulator Contacts: used fine carborundum stone or silicon carbide paper (sandpaper 400 grit or finer).
(ii) Cut-out Relay Contacts: used a strip of fine glasspaper, never carborundum stone or emery cloth.

Voltage Regulator-Electrical Setting

It is important that only a good quality MOVING COIL VOLTOMETER (0-20 volts) is used when checking the regulator. The pulsing nature of the voltage will prevent a digital voltmeter from settling on a single reading.

Remove the cover and insert a thin piece of cardboard between the armature and the core face of the cut-out (contacts) to prevent the contacts from closing.

Remove and join together the cables from the control box terminals A and A1. Connect the negative lead of the voltmeter to the D (output) post on the generator.

Start the engine and slowly increase its speed until the voltmeter needle flicks and steadies, at about 2,000 RPM. The voltage reading should be between the appropriate limits given in Table 1.

If the voltage, at which the reading becomes steady, occurs outside these limits, adjust the regulator by turning the adjusting screw 1/4 turn at a time clockwise to raise the voltage or counterclockwise to lower. The adjusting screw can be found on the back of the regulator facing the firewall.

Adjustment of regulator open-circuit voltage should be completed within 30 seconds otherwise heating of the shunt windings will cause false settings to be made.

Remove the cardboard.

NOTE: The voltage that you see in Table 1 is not the actual operating voltage of the generator and electrical system. It is the voltage that is only used for setting purposes.

Voltage Regulator-Mechanical Setting

A copper separator, in the form of the disk or square, is welded to the core face of the voltage regulator (the coil with just a few heavy gauge wire windings) and affects the gap setting between the core-face and the underside of the armature as follows:

When a round separator is used, the care gap should be 0.015" (0.38mm).

When a Square separator is used, the inner gap should be 0.021" (0.53mm).

To adjust the air gap:
Slacken the fixed contact locking nut (on top of the bobbin) and unscrew the contact screw until it is well clear of the armature moving contact.

Slacken the voltage adjustment spring-loaded screw (on the back of the regulator) until it is well clear of the armature tension spring.
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Slacken the two armature assembly securing screws.

Insert the gauge (*feeler gauge*) of sufficient width to cover the core face, and of the appropriate thickness, between the armature and copper separator.

Press the armature squarely down against the gauge and re-tighten the two armature assembly securing screws. Without removing the gauge, screw in the fixed contact adjustment screw until it just touches the armature contact. Re-tighten the locking nut.

Re-check the electrical setting of the regulator.

**Cut-Out - Electrical Setting**

If the regulator is correctly set but the battery is still not being charged, the cut-out may be out of adjustment. To check the voltage at which the cut-out operates, remove the control (*regulator*) box cover and connect the voltmeter between the terminals D and E (*the right-hand-most two spade terminals*). Start the engine and slowly increase its speed until the cut-out contacts are seen to close, noting the voltage at which this occurs. This should be 12.7 to 13.3 volts.

If operation of the cut-out takes place outside these limits, it will be necessary to adjust. To do this, turn the adjusting screw (*found on the firewall side of the regulator*) in a clockwise direction to raise the voltage setting or in a counter clockwise direction to reduce the setting. Turn the screw only a fraction of the turn at a time and test after each adjustment by increasing the engine speed and noting the voltmeter readings at the instant of contact closure. Electrical settings of the cut-out, like the regulator, must be made as quickly as possible, because of temperature rise effects. Tighten the lock nut after making the adjustment. If the cut-out does not operate, there may be an open circuit in the wiring of the cut out and regulator unit in which case the unit should be removed for examination or replacement.

**Cut Out - Mechanical Setting**

Slacken the adjustment screw (*on the fire-wall side of the regulator*) until it is well clear of the armature tension spring.

Slacken the two armature securing screws.

Press the armature squarely down against the core face (copper sprayed in some units, fit with a square of copper in others) and re-tighten the armature securing screws. No gauge is necessary.

With the armature still pressed against the core face, adjust the gap between the armature stop arm and the armature tongue to 0.032" (0.81 mm) by bending the stop arm (*the stop arm is the metal all arm on the very top against which the moving armature contact arm (called the “fixed contact blade”) rests*).

Adjust the fixed contact blade so that it is reflected 0.015" (0.38mm) by the armature moving contact when the armature is pressed against the core face.
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Re-check the electrical setting of the cut-out.

Table 1. Open Circuit Settings

<table>
<thead>
<tr>
<th>Ambient Temperature</th>
<th>Open Circuit Voltages</th>
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<tbody>
<tr>
<td>10C (50F)</td>
<td>16.1 - 16.7</td>
</tr>
<tr>
<td>20C (68F)</td>
<td>16.0 - 16.6</td>
</tr>
<tr>
<td>30C (86F)</td>
<td>15.9 - 16.5</td>
</tr>
<tr>
<td>40C (104F)</td>
<td>15.8 - 16.4</td>
</tr>
</tbody>
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