2CV BATTERY PROBLEMS SOLVED

By Graeme Dennes

Revision 6

Circuit Revisions
In Revision 2 and earlier of this article, the Narva 68044 relay was specified, with its coil wire pin 85 connected to +12V from the ignition switch and coil wire pin 86 connected to ground, as shown in the wiring diagrams provided with the articles.

In Revisions 3 to 5, two changes were made to that arrangement, as shown in the wiring diagrams provided:

1. Narva relay 68032 (with internal protection diode) is used in place of the 68044 relay to provide voltage spike protection, and
2. The connections to the relay coil have been (**must be!**) swapped over, i.e., coil wire pin 85 *must be* connected to ground and coil wire pin 86 *must be* connected to +12V from the ignition switch. Failure to do this will destroy the diode in the relay.

In Revision 6, although relay pin 87a is not used, it has been included in the wiring diagram for completeness.

The writer recommends that vehicles wired in accordance with Revision 2 or earlier are modified to include the Revisions 3 to 5 changes, i.e., wired per the arrangements described in this Revision 6 article.

Background
Have you experienced some frustrating battery issues with your 2CV such as the battery being flat or almost flat when it really shouldn't be? Sounds like an undercharging problem? Perhaps you've had battery fluid overflowing from the cell vents onto the battery case, the battery tray and the firewall area near the battery, leaving a trail of white powder and corrosion? Sounds like an overcharging problem? Both of these conditions are caused by faults in the battery charging system, and neither condition augurs well for a long and healthy battery life and happy owner!

Sulphation: The leading cause of battery failure with flooded lead acid car batteries is sulphation, which is the deposition of lead sulphate crystals on the surfaces of the battery plates. It reduces the effective plate area and thus the amount of charge taken in. Major sulphation can develop when the battery is *undercharged or overcharged or stored uncharged*. The source of the lead sulphate is the water and the sulphuric acid which together form the electrolyte within the battery. There is an ongoing electro-chemical reaction taking place, and when the battery is maintained at its correct fully charged point, the battery chemistry is at an optimum state and lead sulphate deposition is minimized.

If the sulphation is allowed to continue, the charge taken in continues to be reduced, exacerbating the sulphation. This is a downward spiral to where the sulphation deposits will eventually prevent the battery from taking in sufficient charge to start the engine. At that point, the battery has reached the end of its useful life and will need to be replaced, usually at a most inconvenient time and place!

Water loss: Gassing (bubbling at the surface of the electrolyte) occurs naturally during normal charging, and results from the water in the electrolyte being broken down into its constituent hydrogen and oxygen (gas) molecules through electrolysis. The resulting water loss can destroy the battery if the electrolyte level falls below the top of the plates. Should this happen, the exposed plates will sustain damage and the battery's capacity and life will be impacted.

Excessive gassing: One of the hazards of overcharging is excessive gassing, where the electrolyte can overheat and produce excessive hydrogen and oxygen gasses which “boils off” (depletes) the water in the battery.

The most hazardous situation is when a lead acid battery is overcharging *and* overheating, producing more combustible hydrogen and oxygen than can be vented, until finally, the pressure is relieved – instantly – by explosion. You definitely don’t want this to happen anywhere near you or under the bonnet of your car. Hot sulphuric acid is not a nice friend!

If the battery is being undercharged or stored uncharged, sulphation occurs, whereas if it is being overcharged, sulphation and excessive gassing occur. Either state has an impact on battery health. To ensure these conditions don’t occur, it helps to understand why they occur and how to prevent them.

Come on Baldrick. Speak up!
Um, yes m’lord.
The battery: Supplies power to the car’s electrical systems, equipment and accessories before the engine is started. It supplies power to the starter motor when starting the engine. Very importantly, the battery acts as a voltage stabiliser for the alternator, stabilising the voltage fed to the car’s electrical system. (More follows).

The alternator: Acts as the battery charger for the car’s battery and provides the electrical power for the car’s electrical systems and equipment while the engine is running.

The voltage regulator: Controls the output voltage of the alternator so the battery is optimally charged and maintained in an optimal manner to maximise the battery’s life.

Well Baldrick…?
As shown on the circuit diagram at the last page, the 2CV voltage regulator has three electrical terminals. These are named D+ (Dynamo+), D- (Dynamo-) and DF (Dynamo Field). Although car alternators have been around for some 60 years, the earlier Dynamo (Generator) terminology has generally remained in the automotive electrical industry.

Consider the voltage regulator wiring for the 2CV. The regulator’s D+ terminal connects to the battery positive terminal via the ignition switch, the D- terminal connects to the battery negative terminal via the chassis ground connection, and the DF terminal connects to the rotor of the alternator to regulate the battery charging. Refer to the writer’s article, 2CV Battery Charging Circuit for more details.

The D+, D- and DF wires terminate at a three-pin socket (shown on the circuit diagram) which connects to the three pins on the bottom face of the standard voltage regulator. This forms the 2CV voltage regulator wiring and battery charging arrangement as it was manufactured.

As background, the standard 2CV voltage regulator is an adjustable electro-mechanical device. It can lose its calibration over time, resulting in the battery being either undercharged or overcharged. Adding to this is the fact that the regulator is now several decades old and much older than Citroen ever envisaged its working life would be.

Mmmm, he says knowingly… By now, the voltage regulator in your 2CV may be well outside of its specifications and require recalibrating. Yes, that may return the voltage regulator back to specifications, but because of the regulator’s age and wear, expecting it to retain its calibration could be futile, so it may not be very long before it has to be done again, by which time the battery has been through another period of longer-term damage and the car owner has been through another period of (aaaaaaagh!!!!!!!) frustration!

But it gets worse m'Lord.
Worse? Surely not.
Not only does the original electro-mechanical voltage regulator lose its calibration over time which results in the battery being either undercharged or overcharged, but there is a further issue of even greater significance affecting the health and life of the 2CV battery.

How do we maximise the health and life of the battery? By ensuring the voltage regulator can sense the **true** battery voltage. This can only be achieved if the wiring resistance between the regulator and the battery is zero ohms. However, as all wiring has resistance of some amount (well, above zero Kelvin!), we need to take steps to **absolutely minimise** the wiring resistance between the regulator and the battery.

Why is the wiring resistance of importance Baldrick?
Any wiring resistance between the regulator and the battery *will guarantee that the true battery voltage will never be sensed by the regulator!!*

The regulator's D+ connection senses (measures) the battery voltage at the ignition switch, which may be perhaps half a volt lower than the true battery voltage. For example, say the battery terminal voltage is 14.2V when the engine is running. We consider the battery to be fully charged or close to fully charged when it reaches 14.2V. However, due to the half volt dropped across the wiring resistance between the battery and the ignition switch, the regulator's D+ terminal will sense 13.7V (from the ignition switch) as the battery voltage!

Come on Baldrick. Don't hold back!
Here is the nub of the issue. Continuing with the example. With 14.2V at the battery terminals, the battery is considered fully charged, so we want the alternator to reduce its output so the charging rate of the battery is reduced, so the battery doesn't enter the overcharged state. *That is what is required.* Yet at that *very* same instant, the voltage regulator is sensing 13.7V at the ignition switch as the battery voltage. Thus the regulator is being told the battery is still not up to full charge, so it cracks the whip and keeps the alternator charging the battery at its maximum rate, driving the already-fully-charged battery headlong into the overcharged zone! *That is what is achieved!* (Ah, now I know what that "boiling" sound is!!). This is how the 2CV was manufactured, and is a constant predicament facing all 2CV owners, *whether they know about it or not!* In fact, this was a design compromise adopted by *most* of the car manufacturers of *most* of the vehicles made over *most* of the last century!!

In summary, the overcharging of the battery has come about because of this **small** voltage drop across the wiring resistances between the regulator and the battery due to the numerous electrical currents flowing in the wiring. This small voltage drop is sufficient to convince the regulator to *always overcharge the battery!* Yes, it's a sure-fire way to guarantee electrolyte overheating, excessive gassing, loss of water from the cells, damage to the plates by sulphation and damage to the plates from not being covered by fluid. Yes, the battery is hurtling flat strap towards its twilight zone! *Keep in mind that this relentless, unwanted overcharging of the battery is not caused by the voltage regulator. It's caused by the vehicle's wiring resistance!!*

Alright Baldrick. What is your cunning plan?
This article describes a small modification to the 2CV electrical system to ensure the battery is charged in an optimum, controlled manner by using a modern solid-state voltage regulator, the Bosch RE57, in conjunction with a relay. The RE57 regulator sets the correct battery charging conditions and the relay bypasses the wiring resistances. The RE57 regulator and relay ensure the battery is neither undercharged nor overcharged but optimally charged, promoting longer battery life! Utopia! The battery is optimally *charged* to its fully charged state and is optimally *maintained* at its fully charged state! Yes, a perfect solution to achieve a long battery life **and** a very happy owner!

This is the most cunning plan a Baldrick has had for five hundred years!
The RE57 regulator and relay, when wired in accordance with this article, will ensure the battery is always optimally cared for. The RE57 regulator and the battery will be on the same voltage page! Note, however, that this doesn't dispense with the need to be vigilant about keeping an eye on the battery fluid levels. Ensure the plates are *always* covered by fluid. Add distilled water as necessary. Note: There is nothing preventing a relay from being wired to the original electro-mechanical regulator in a similar manner so the true battery voltage is sensed, but it does depend on the (now) old voltage regulator maintaining its calibration as noted, otherwise no benefit will be gained because the battery will still end up being overcharged or undercharged! Nothing gained.

Although this article applies to the 2CV, the underlying principles apply to other vehicles which employ an external three-terminal electro-mechanical voltage regulator controlling an alternator.

On the left is a photo of the Bosch RE57 voltage regulator, packaged in a small metal die-cast case. It is a sealed, non-adjustable three-terminal (D+, DF, D-) device which provides an install-and-forget solution. It has a voltage set point of 14.2V. More follows. The regulator's metal case is a heatsink, so mount the unit firmly on the firewall.

Note: A similar voltage regulator is the Bosch RE55 which is a two-terminal device. It uses the metal case of the regulator as the D- terminal and this connects to the battery via the vehicle body. Don't use this regulator. You want the three-terminal RE57 regulator with the separate ground pin which can be wired *directly to the battery negative post* to achieve an electrically "stronger" (i.e. more direct) connection. If someone tries to convince you the RE55 will do the same job as the RE57, they definitely don't understand the intricacies of voltage regulation and the effects of even milliohms of wiring resistances on the safe charging of a battery!

So what have you got for us Baldrick?
The attached circuit diagram shows the modified wiring needed to connect the RE57 voltage regulator and relay to your 2CV to replace the original electro-mechanical voltage regulator. Briefly, when the ignition switch is turned on, the original D+ (12V) connection from the ignition switch is used to activate the relay. When the relay is activated, its closed contacts connect the D+ terminal of the RE57 regulator to the battery positive post. So now, with the RE57 regulator's D+ and D- terminals connected *directly* to the battery posts, the RE57 can finally sense the *true* battery voltage and ensure the battery is properly charged and kept properly charged.

At the lower section of the circuit diagram is shown the pin layout diagrams and pin designators for the original 2CV regulator, the RE57 regulator and the Narva 68032 relay and 68084 socket **when looking directly at the connection pins, as is noted**. (This is the industry standard practice for viewing device pins). As may be seen in the photo above, the pinout for the RE57 regulator is also provided on the top face of the regulator, just below the "RE57" designator. After attaching the small metal mounting bracket supplied with the relay to the relay cover, mount the RE57 regulator and the relay and socket next to each other on the firewall, close to the battery, with their connection pins pointing downwards. Three short wires with spade crimp terminals can be made up to extend the three connections (D+, D- and DF) from the original regulator socket. Alternatively, the socket could be removed and the wires extended. The D+ and D- wires connect to the relay coil while the DF wire connects to the DF terminal on the regulator. Note that although relay pins 87 and 87a are joined internally in the relay, pin 87a is not used.

The colours of the three wires at the original regulator socket may vary and sometimes they are all the same colour! Photograph, trace, label and record the socket wiring details **very** carefully and keep the information in a safe place.

The photo at left shows the underside view of the Bosch RE57 regulator with its three connection pins. Note the end of a resistor projecting above the epoxy fill. If the exposed resistor wire is cut, the regulator's voltage set point is increased from the default of 14.2V to 15.2V. This compensates for diode-isolated charging situations such as in dual battery setups, where voltage drops occur across the diodes.
For single battery installations ala 2CV, use the default voltage set point of 14.2V, ie, **don't** cut the resistor wire! (Note: not all RE57 regulators provide this voltage selection option.)

The Bosch RE57 regulator and Narva relay and socket are usually available at auto parts stores, and often appear on eBay. Do a web search for "Bosch RE57 regulator". Don't use substitute products for the voltage regulator, the relay or the socket. Below is a photo of the relay.

Four wires connect to the relay socket via brass spade connectors and these are pressed into and locked in the bottom of the relay socket after being crimped to the wires. Identify the correct orientation for the brass spade connectors *before* inserting them into the relay socket. These connectors are usually supplied with the socket. Three red-coloured crimp connectors are needed for connecting to the RE57 voltage regulator pins. Two crimped connectors of a size suitable for mounting under the battery post bolts are needed to connect the regulator D- terminal to the battery negative post and to connect pin 30 of the relay socket to the battery positive post. Ensure all crimps are correctly fitted to the wires using correctly sized and adjusted crimping tools.

Keep the wiring between the RE57 regulator, the relay and the battery as short as practicable. Terminate the red and black wires *directly at the battery posts* – no other place! A suitable wire size for the connecting wires is a *conductor* diameter of 1.5 mm.

Run, dress and secure the wiring in a professional manner. Make it reliable and neat, and make the RE57 regulator, the relay and the wiring appear to be originally fitted parts on the vehicle. Be proud of your work!

Final Electrical Checks.
Do the following checks to confirm the rest of the car's charging system is in good condition:

1. Ensure all electrical wiring, connecting/terminating screws, bolts, washers, nuts and all crimped wiring terminations discussed below are disconnected, brass-wire brushed on all surfaces to remove all oxidation and corrosion products, and then reconnected and solidly tightened. Ensure all crimped connections provide a solid connection, otherwise replace the crimp. This sequence of checks provides the pathway to achieve the lowest-possible wiring resistance and the highest reliability for your car's charging circuitry.
2. Ensure the heavy starter cables at the battery posts are solidly connected to the battery.
3. Ensure the heavy positive cable is solidly connected to the starter solenoid.
4. Ensure the heavy negative cable is solidly connected to the gearbox stud.
5. Ensure the battery negative post is also solidly connected to a metal grounding point on the firewall with a 3mm (minimum) diameter copper cable. (This is the *conductor* diameter, not the insulation diameter).
6. Ensure the D- wire at the original regulator socket is solidly grounded to the firewall.
7. Ensure the DF wire at the original regulator socket is solidly connected to the alternator rotor terminal.
8. Ensure the alternator's output terminal is solidly connected to its crimp connection, and the crimp is solidly connected to the cable.
9. Ensure the alternator body (negative) is solidly grounded to the exhaust manifold on which it is mounted. Ensure the mounting bolt, washer and nut are tight.
10. Ensure the ground wires from the wiring loom are solidly connected to the ground stud on the firewall. These will have been in place for a long time!
11. Poor ground connections seem to be the eternal bane of the 2CV. Every ground connection should be disconnected, thoroughly cleaned and replaced *tightly*.

Some of the above connections may never have been disturbed since the 2CV was new. Take your time and do the job once, do it thoroughly and do it methodically, one step at a time. Make it right.

Re crimped vs soldered connections. A correctly crimped terminal creates a metal-to-metal colloidal bond at the surfaces between the wire and the terminal. If done correctly, no void (space) remains between the separate strands of the wire and between the wire strands and the crimp, and the two metals become as one. This ensures very low resistance, mechanically strong and long-life connections. This is the preferred joining mechanism. If we were to use solder to join the wire to the crimp, the current flowing must pass through the solder, and the resistivity of 63/37 solder is around ten times the resistivity of copper, exacerbating the wiring resistance problem! Remember, series resistances are additive.

Re crimped connections. Achieving high quality crimped connections requires (1) *correctly-adjusted*, good quality crimping tools; (2) *professional-quality* crimp terminals and (3) *correct usage* by the operator! Cheap, improperly operating crimping tools and poor quality crimp terminals abound in our shops, and if these are used, the result can be an abject failure, after which the blame is usually passed onto the crimp terminals as being the cause of the problem, or else the bad connections stay hidden until they start to impact on the operation and reliability of the vehicle. **One is usually unable to remove a crimped terminal by hand from a wire if it has been crimped correctly!** Have a practice run. Test every crimp in this manner to confirm its integrity before putting it to use.

In summary, the long-term success and trouble-free operation of your installation depends primarily on the **quality** of the crimp terminals used and the **quality** of your handwork.

The finish line!!
After the job is finished and your State's Electrical Licensing Inspector has inspected your work and issued a Certificate of Compliance – only joking!! – start the engine and turn on the lights.

After a couple of minutes of running, the voltage measured at the battery posts should be around 13.0V at idle. With the engine running at perhaps 2000 RPM, the battery voltage should be around 13.5V to 14.0V, reaching a maximum of 14.2V around 3000 RPM. **It should not rise above 14.2V, the regulator's voltage set point, at any engine speed.** This confirms the modification is working as intended. Congratulations!

Anecdotally, many external voltage regulators from all vehicle brands have been replaced in the past in valiant attempts to fix overcharging problems which were eventually found to be caused by wiring resistances between the voltage regulator and the battery! Much money was spent and much money was made!

Finally, if a vehicle is not being used regularly, as can happen with our classic cars, connect a good quality multi-stage battery charger to the battery to maintain it at its best state of health. It maximises the life and reliability of the battery, ensuring it will be fully charged and ready to operate our 2CV the next time we decide to take it out for a drive.

On a somewhat similar vein, recent advice provided to the writer by an industry insider is that after several years of operation, some Citroen vehicles equipped with alternators and electro-mechanical voltage regulators could experience an electrical malaise which caused the car's headlights to pulse in brightness when the engine was running around 1500 RPM with the headlights on and with a fully charged battery. If the problem arose, the solution was to fit the relay (only) as described herein.

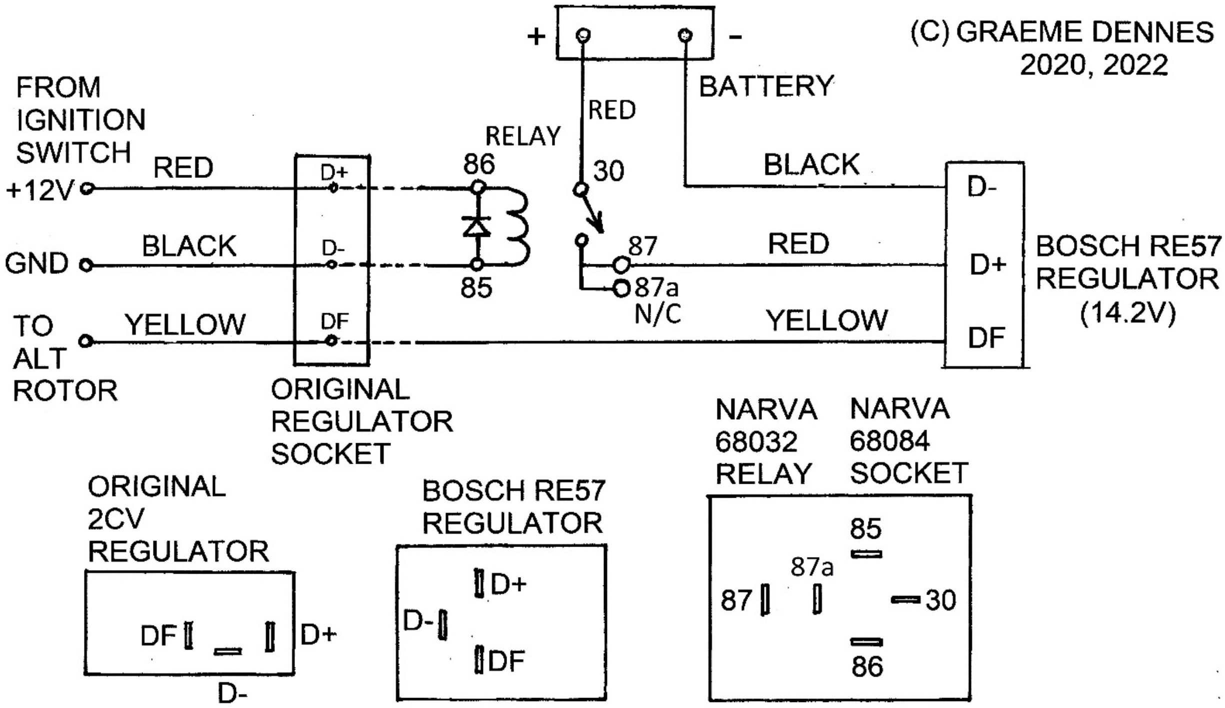
An Important Warning

To prevent extensive and expensive electrical system damage to your vehicle:

Never disconnect the battery when the engine is running!

The battery loads the alternator and stabilises the entire electrical system, preventing high peak voltages (perhaps up to 100 volts) and voltage surges occurring. These can damage the vehicle's electrical/electronic systems and equipment, including the vehicle's management computers, alternator, voltage regulator, ignition system, Sat-Nav, radio, light globes, etc, etc. $Ouch, $Ouch!!

2CV REGULATOR - RELAY WIRING



PIN DESIGNATORS SHOWN ABOVE ARE
WHEN LOOKING DIRECTLY AT THE PINS

My grateful appreciation and acknowledgement is given to the web sites from which images have been accessed.

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