Why does a starter motor not turn over?

Turn the ignition key to start the engine and all you get is a "Clack" from the solenoid, or perhaps even a "clac-clac-clac-clac" sound. As you realize that the starter motor won't turn over you get that sinking feeling, wondering what is going on. The answer is not as easy to explain as to describe but here Nic Houslip explains the checks you can make and some of the background information you will need.

First check the state of the battery

Of course, the first thing to do is to determine if the battery is discharged – flat or nearly so. You can check this by turning on all the lights, including the headlamps. If they appear reasonably bright then the battery is not flat but if all you get is an orange glow then all that should be needed is a battery charger. Note: it is of little use measuring the battery voltage with no load because without a load on it, a lead acid battery may well indicate 12V (or 2.0 Volts per Cell) but this gives no indication of its capability. If the battery appears to be reasonably well charged and when you try to start you get the clack sound, it is certain that the problem is corrosion on the battery terminals. Why is this?

Corrosion of the battery terminals

The phenomenon is curious and not well understood, but is common and has a sting in the tail, of which, more later. Before we get into the mechanics of this there are a couple of things I want to explain so that you can grasp what is happening. Most of us will have heard of **Ohm's law**, (no relation to OHMS as James Bond was). Georg Simon Ohm was a German physicist who wrote the famous law that states that "the current through a conductor between two points is directly proportional to the voltage acaoss those two points". In simple terms, if you apply a Voltage (in Volts, abbreviated as V) to a Resistor then the current in Amperes (symbol I) that flows will be proportional to the voltage applied. Resistors have a value of resistance measured in Ohms (abbreviated R or the Greek letter Omega Ω). Since I is proportional to V the law can be manipulated to determine any value that is unknown if the other two are known.

Diagram 1

As an example, and using numbers that are easily calculated in one's head, if V = 12Volts and I = 1 Ampere, then using the formula **R = V divided by I** then we get 12 Ohms. Furthermore, we can rewrite the formula as I = V divided by R which equals 12/12 or 1 Ampere. That should be enough of Ohms law for the explanation, but just remember that every conductor has some resistance. Sometimes very small and often a nuisance, at other times higher, intended to do something in a circuit to help its operation.

In a car starter motor circuit, the battery is connected to the starter motor terminal by a very thick wire, because thick wires tend to have very low resistance and **when the starter is operating it may have to carry currents as high as 300 Amperes**. Think of Ohm's law, if the resistance of the wire was 0.001 Ω (or 1 milli Ohm) and the current flowing was 300 Amperes we could calculate, by rewriting the formula to I x R the voltage across the ends of the cable if we had a meter with long enough leads. It would be 300 A x 0.001Ω or 0.3 Volts. Electrical engineers would refer to this as 300 mV (milli Volts).

OK I hear you say, what does this all mean? Well, if you have only 12V from the battery to drive the starter motor the loss of voltage in the wire must be deducted from the voltage at the motor. In this example, the difference between 12V and 11.70V is very small; but if the figure for the wire's resistance were increased by a factor of 10, say from 0.001Ω to 0.01Ω the calculation is changed greatly. 300A x 0.01Ω then becomes 3.0 Volts lost in the cable, and deducting that from the 12V we started with means that we have only 9V left to turn the starter motor. This may only seem a small amount, but the power of the starter motor, which is calculated as P Watts, from formula **P=V x I** now becomes 12V x 300A = 3,600 Watts (about 4.8 HP) and at 9V x 300A = 2,700 Watts (3.6 HP) you can see that it will materially affect how well the starter turns the engine over as **that 3V difference accounts for about 1.2HP**. You may be wondering where does the energy in the cable go to? It is lost as heat from the cable, in this case, which is rather extreme, there is loss of 3,600 – 2,700 or 900 Watts.

Let's look at the electrical circuit from the RV8

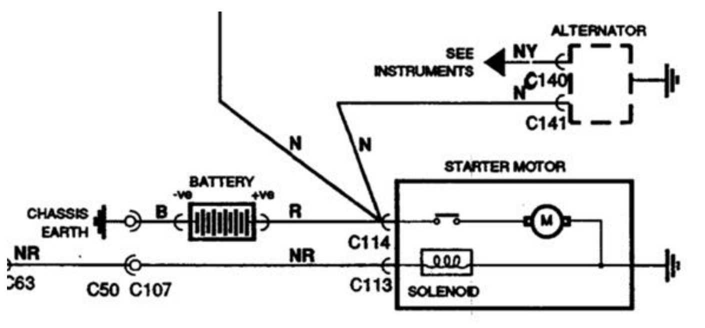

Diagram 2 (see a larger copy of the diagram on page 3)

The electrical circuits from the RV8 and MGBGTV8 are similar in principle but the wiring diagram is more complex as it is all on one page! The battery is the source of power and can deliver a large current to start the engine. This **current is so large that a normal switch isn't capable of handling it, so a "Solenoid" is used. This is a heavy current switch** that is operated by an electromagnet (a coil of wire around an iron core) that attracts a movable armature carrying a contact piece that connects the battery to the starter motor. In the case of the RV8 and MGB and derivatives like the MGBGTV8 (but not MGAs), the solenoid also has another function. As the solenoid is moving the contact piece it, by means of a lever, also **moves the starter pinion into engagement with flywheel ring gear**. The battery feed is connected to the starter at **C114** (see diagram 2 above), the large copper stud and nut. The solenoid is fed in from **C113** which in turn is fed via **C63** from the starter relay.

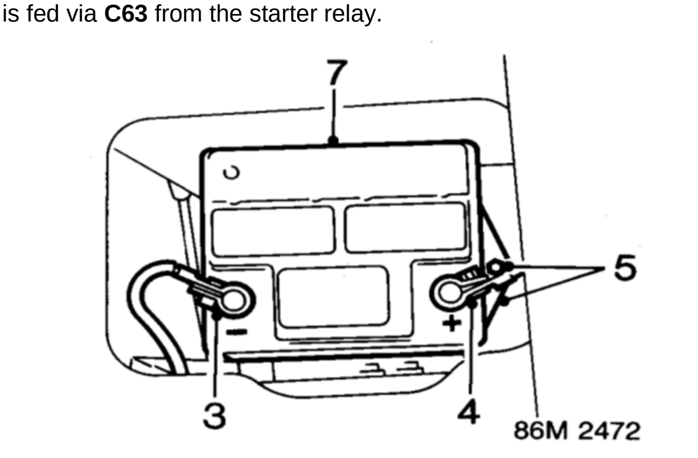

Diagram 3

Why does the solenoid "clack"?
Now let us get to the nub of the issue. Why does it go "clack" or "clac-clac-clac-clac"? If you look at a battery you will see that protruding out of the top of the battery case are two lugs or pillars. These are the connections to the internal workings of the battery and this is where the corrosion (or more correctly sulfation) occurs. Looking at the diagram above you will see the clamp type terminals **3** and **4**. Older cars such as the MGBGTV8 may have Lead cap shaped terminals with screw in the top. These are sadly more prone to corrosion than other types. The sulfation occurs because the battery uses a dilute solution of Sulfuric acid in distilled water as the electrolyte and this is always present near the terminals as it is almost impossible to seal the terminals into the plastic battery case.

If a layer of corrosion should build up between the clamp and the post it can interfere with the current flow, but just to make it more complicated, the sulfation doesn't follow Ohm's law! So, there can be a situation when you turn on the ignition, see the lights on the instruments come on because the sulfation can carry the few amperes need for that. The voltage "dropped" across the sulfation, like that lost in the starter motor cable may be only a fraction a volt. But when you try to start the engine, the solenoid itself draws a much larger current and because the sulfation doesn't obey Mr. Ohm's ruling, its resistance changes and the voltage dropped increases to the point where the solenoid can no longer pull in. If the sulfation isn't quite as bad, then the solenoid will pull in, but as the starter motor then draws a larger current, the sulfation will defeat it, and the solenoid will drop out and the voltage rises until the solenoid connects the motor again and promptly drops out again giving the familiar "clac-clac-clac-clac" sound.

The sting in the tail is that the sulfation also plays a role when the battery is being charged by the alternator. You will note from Diagram 2 that the Alternator output is connected to the starter motor heavy terminal **C114**. The alternator has a clever device built into it, a voltage regulator that "senses" the battery voltage at the output terminal of the alternator at **C141** in Diagram 2. As the alternator forces current into the battery the voltage of the battery rises, indicating that it is fully charged, when the regulator reduces the charge current. The sneaky sulfation acting as a non-Ohm's law resistor changes its resistance with current flowing through it, tricking the alternator regulator into thinking the battery is charged and reducing the charge current to what is essentially a trickle charge. The sulfation causes you to have an undercharged battery anyway and puts a barrier in the way of correct starting. If you do manage to get the engine started (perhaps by using jump leads) and run at night, all will work OK as the alternator will sense the load from the headlamps, radio, heater fan etc. which are connected to the starter terminal and adjust the alternator's output to keep the lights at full brightness.

What's the solution?
First clean up the battery and terminals. With the car outside, pour a jug or kettle of hot water, as hot as you can bear it, over the battery, terminals and if there is any corrosion on the battery carrier, pour it on that too. This will remove surface grime and the majority of the sulfation on the terminals and clamps. The advantage of hot water is that it evaporates and it is much easier to dry off with a cloth or paper towel. Now remove the terminals, Negative first (**Black or marked –**) followed by the Positive (**Red or marked +**). Doing it in this order avoids the possibility of shorting the battery should the spanner being used to loosen the Positive clamp bolt, accidentally touch the body of the car.

Now you must clean the mating surfaces of the clamps and the pillars or posts back to bright metal. A small wire brush is useful, sandpaper works too but you must clean off all the sand after using it. If the sulfation is hard, a sharp knife can be used carefully. If any of the bolts are bent or damaged it is worth replacing them with new, plated ones, as the old ones are often bent by overtightening.

Now you need something to prevent further corrosion. There used to be a product called **No Crode**, made by Holts, but it seems now to be NLA. Not to worry, take about a teaspoon of Vaseline in a small container and mix about ¼ teaspoon of bicarbonate of soda with it. Quantities are not critical, I find the handle end of the teaspoon picks up about ¼ teaspoon. Smear the terminal posts and the clamps liberally with this material before replacing the clamps (remember Positive + First!) and again after tightening the bolts. This should keep them from corroding for a long time.


The belt should look like this. If it doesn't, Clive Wheatley has stock of the correct item.

While doing these jobs, **check the water level in the battery is correc**t, add distilled water if needed. At the same time, it is a good idea **check on the condition and tightness of the alternator belt**. The belt must deliver a large amount of power to the alternator and as its pulley is a small diameter compared to the crankshaft pulley the belt must be flexible and have a toothed inner to allow it to bend to the radius of the pulley. Tighten as specified in your hand book or workshop manual.

Just for information, an alternator charging at 35 Amperes is delivering about 500 Watts to the battery. Allowing for frictional and other losses, the belt needs to deliver at least 1 Horsepower to the pulley from the crankshaft. The belt should look like this

Other stuff that might be helpful

Measuring very low resistance values (less than 1/10 of an Ohm) is difficult, but it is interesting to connect a volt meter across any junction and measure the voltage drop across it. You may be surprised! The object is to have the lowest voltage drop across any junction.

Ohm's Law

There are 3 formulae in Ohm's law that you can use.

$$I = \frac{V}{R} \quad \text{or} \quad V = IR \quad \text{or} \quad R = \frac{V}{I}.$$

Calculate the unknown on the left of the = sign by following the appropriate formula.

Power in a circuit

Power in Watts is given by multiplying the voltage V by the current I.

Different types of Resistors

All resistors, indeed all conductors, have a Temperature coefficient, which is an indication of a how much the resistor value (in Ohms) changes with temperature. Most are Positive (PTC) meaning the resistance increases with increasing temperature. The filament in a light bulb is a good example, if you measure the resistance of a Halogen lamp filament you will find that it is quite low, perhaps as little as 0.1 Ohm. If you calculate the resistance from the voltage applied and the current flowing through it you will find it is much higher.

Using Ohms law, we know both V & I, so R = voltage divided by current. 12V/5 = 2.4 Ohms

Negative Temperature coefficient (NTC) resistors are less common; their resistance decreases as they are heated. Many of the sensors used in RV8's to sense temperature or incoming air,

Larger copy of Diagram 2

coolant or fuel are resistors with precise characteristics related to temperature. The change in resistance is measured by the Engine Control Unit 14 CUX and converted to a temperature.

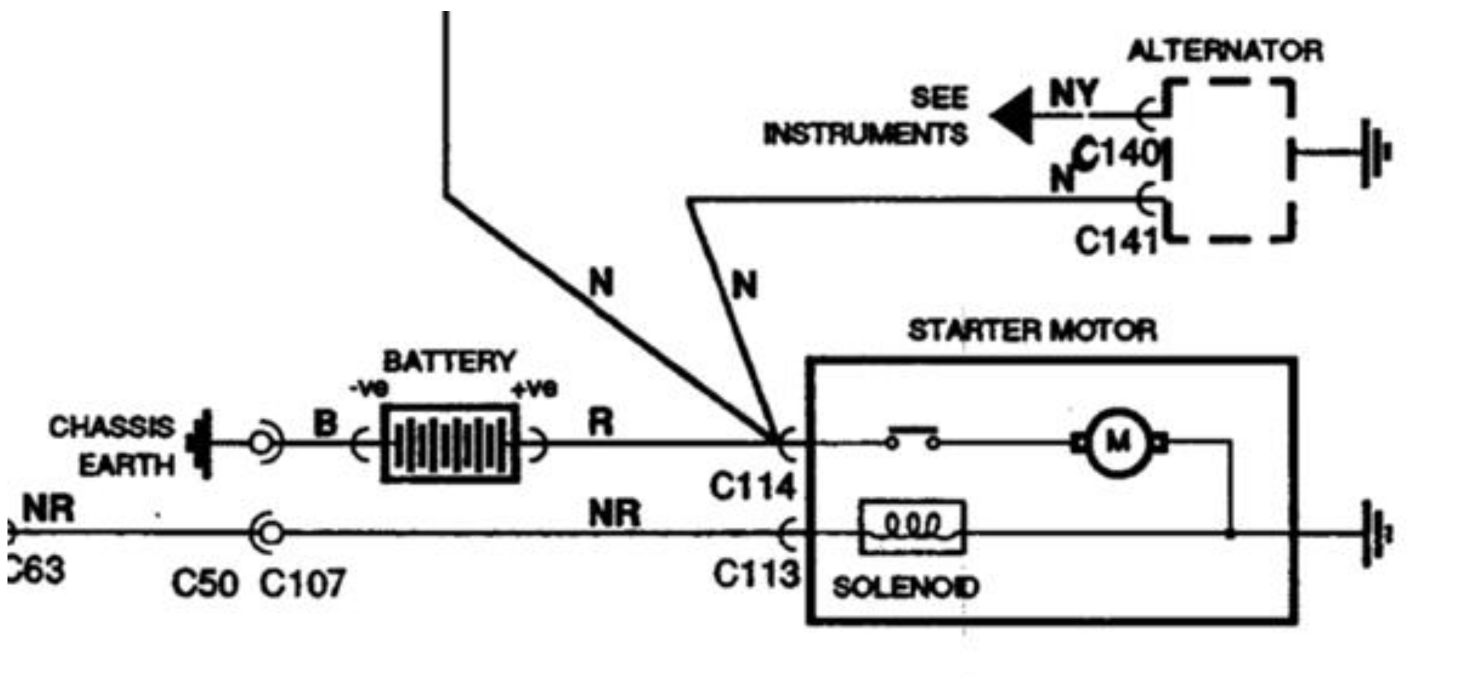

Diagram 2