Electrical System "Grounding"

Many owners have taken great pains to connect the power going to an electrical device with special wire, connectors and fancy heat shrink tubing over the connections. Then they wonder why their headlamp, ignition or other component doesn't work well. It's really very simple. Faulty electrical "grounding" contributes to about 70% of the motorcycle wiring issues on the older classic bikes. It's therefore very important to understand two simple electrical concepts in order to avoid these type problems.

Concept A – The Circuit

What people forget is that they are dealing with an electrical circuit. "Circuit" comes from the Latin word for "circle", and that's the best way to describe what's going on. For the sake of explanation consider another circle, the spoke wheel. If you somehow installed a bad wheel bearing, then the whole wheel would spin slowly or maybe not at all. It doesn't matter how much money you spent on perfect rims, tires or spokes, the one bad bearing slows down everything. Electricity acts very much the same. The flow of electricity throughout an *entire circuit* is controlled by the most restrictive portion of that circuit.

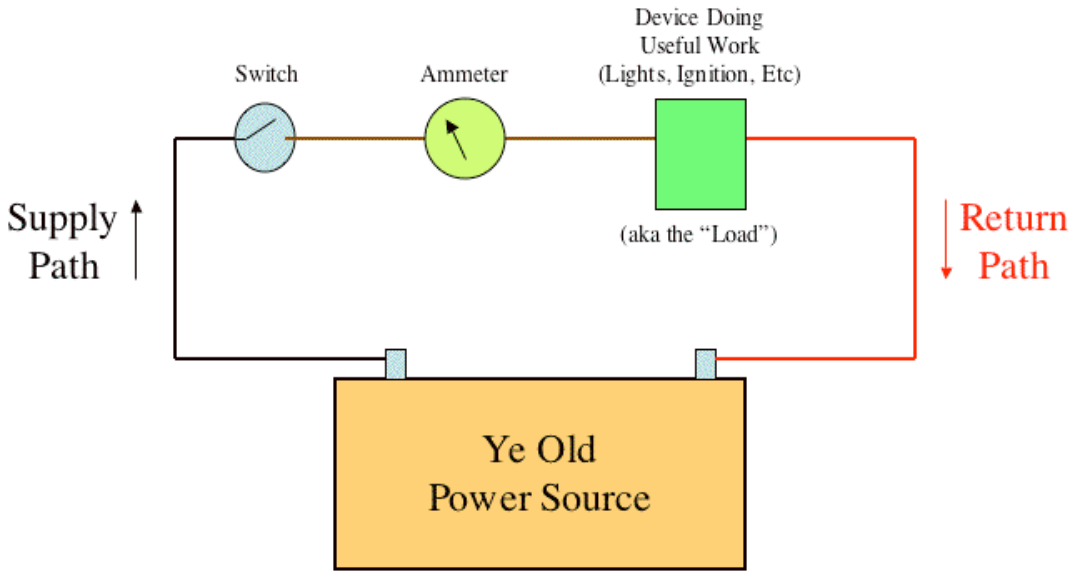

Fig.1: A circuit is a circle

Concept B – Current Flow

Another important electrical concept is like your engine's oil tank. If you run your engine while peering into the oil tank, you'll see that engine oil is being returned at a high flow rate. However, you will also note that the fluid level within the oil tank never rises. This is because oil is being sucked out of the bottom of the tank at the same rate it's being returned back into the tank. Electricity also behaves in the same manner. The *total* amount of electricity leaving any device equals the exact amount of electricity returning to that device. Stated another way, if the component is the battery for instance, if electricity doesn't have a "round trip ticket" back to the battery, then it simply doesn't bother to ever leave the battery.

To understand “grounding” it is best to go all the way back to the beginning and walk through the growth of the technology. You’ll clearly see these concepts applied.

Grounding in the 1950’s

If you have a very old British bike from the 1950’s equipped with a 6-volt electrical system you may find that there are no ground wires within the harness. Ground wiring was simply not common practice back then on cars or motorcycles. The result was a bad reputation for 6V lighting, and Joe Lucas in particular. All manufacturers generally considered the steel frame of the vehicle to be a suitable electrical return path. No one wanted to spend money on copper wire when they could simply use the frame. Using the frame is a good idea, but only as long as the vehicle is never taken out in rain or snow. Once water is introduced, corrosion begins, and electrical connections to the steel become a very “iffy” prospect.

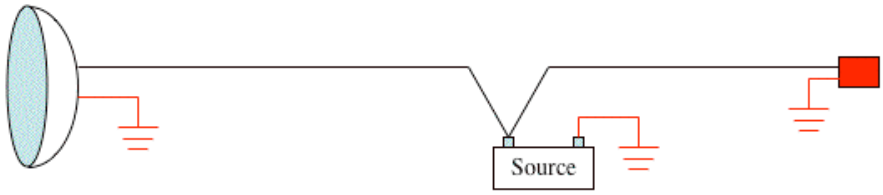

Fig. 2: Typical 1950’s wiring using the frame as an electrical path

Although it’s true 6V lighting isn’t as good as its 12V cousin, a lot of its bad reputation is simply due to the use of the frame “grounding” concept. Once the owner of a 1950’s era vehicle brings the harness up to the later standards by adding return wires to the headlamp and other components, they always see immediate and remarkable improvements.

It is important to remember that if you are depending on a frame ground for one or more components then your potential for trouble is much worse than you think.

• As you can see from Fig 2, there’s the risk of a bad connection going “into” the frame, then another coming back “off” the frame.

• Then again, suppose you run your headlamp through a frame ground on the forks. You not only have these 2 rusty connections, but the added resistance of electrical flow through the head post bearings. As pointed out in Concept 2, all these “choke points” add up and reduce the available voltage. The result of either scenario is a very dim headlamp.

• If frame grounds reduce the voltage to the lights, then they might also reduce the battery charging voltage too. So the 12V battery could be loosing 2V of charging voltage, and the wiring to the lights might be loosing an additional 2V... all due to rusty frame “grounding”.

Grounding in the 1960’s

In the 1960’s most manufacturers (including Lucas) introduced a ground wire to the headlamp for safety. On most Brit bikes after 1964, if you open the headlamp shell you’ll see RED wires built in to the harness. This greatly increased the brightness and reliability of the headlamp. Still, the other lamps and components (notably the tail lamp) were left to fend for themselves. Therefore most owners of mid-60’s British motorcycles find that the overall lighting’s reliability can be improved by adding the missing return wires to the tail lamp, gauge lamps and other electrical components.

A common repair today on Lucas systems made the mid-1960's is dim headlamps. Upon opening the headlamp shell you may find the RED ground wire coming up through the main harness is not connected or partially connected. On most Brit bikes built during the 60's and 70's, this RED wire should connect to a 4-way socket connector. The 3 new leads coming out of the connector then connect to: 1 directly to the HL bulb connector, 1 to the shell (for blinkers), and 1 to the green Hi Beam indicator. Of course, the key component is the 4-way connector, most of which need replacing on these older bikes. The thin metal conductor inside the black rubber sleeve breaks into multiple pieces after 30+ years and then presents intermittent connection issues, resulting in reduced voltage. So, although the copper return wire is present, the busted connector keeps it from doing its proper job.

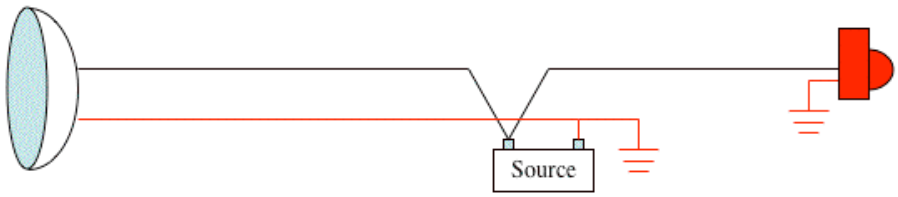

Fig. 3: Typical 1960's wiring using the frame as a partial electrical path

Norton started to have fully wired grounds around 1969, but then the rubber mounted Commando engines had to. Finally by 1971, Triumph and BSA started running RED return wires to the tail lamp and most important components.

The latest and best practice

It was not until the mid-1970's to mid-1980's that 2 major concepts came together to define what we now consider as "best wiring practice" for motorcycle and automotive wiring. When both practices are combined, and used together, they almost entirely eliminate vehicle electrical problems. On all vehicles it is now considered "best practice" to do 2 things: 1) use a copper wire as a return path in place of the "grounded frame" approach, and 2) collect all the return wires at a single "common" point, better known as the *Single Point Ground* (SPG).

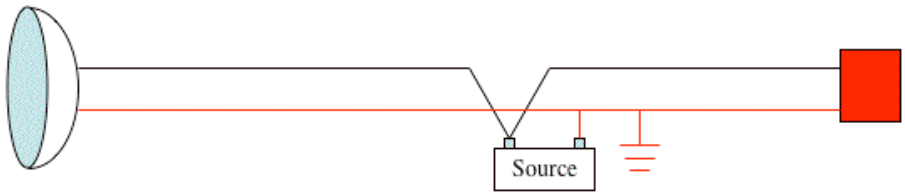

Fig. 4: Typical 1980's wiring using a return wire to every component

<u>Return Wiring</u>

As simple as it sounds, it simply took a long time to figure out that copper wire was a much better material for moving electrons than a rusty steel frame. By using copper wire for electrical return paths manufacturers found that they had higher and more reliable voltages available. These higher voltages enabled brighter lighting and more stable voltages introduced the possibility of using electronic ignitions.

Single Point Grounds

Once all the components are fitted with their own return wire, by collecting all the return wires at a common point, the SPG works to get the entire electrical system "singing off the same sheet of music". It does this by making sure that every electron has a clear path back to its source, whether it's the alternator or the battery.

In my opinion, the best location for a SPG on most Brit bikes is the base of the stock Lucas rectifier, or a point close to the output of the modern replacement rectifier-regulator unit. This is for several reasons:

a) Lucas collected all their grounds at the base of the rectifier on the stock harness. If you are running a stock or reproduction harness, then Lucas has already done most of the work for you. It makes more sense to simply add new wires to supplement what Lucas supplied.

b) The power your bike runs on originates at the alternator, not the battery. However, you cannot connect directly to the alternator because its producing AC power and everything on the bike needs DC. So the next best place is the rectifier, which converts AC power from the alternator into the DC your electrical system requires for operation. If you need more information on this, see the GABMA tech article on *Electrical Myths*.

c) Stacking numerous connections on the battery ground post is an invitation to corrosion. There's simply too much battery acid around the battery terminals to keep the connection surfaces pristine. As with the steel frames, corrosion-free metal is always required for good electrical connections.

When all 3 reasons are considered, it's much better to stack all system return wires on the clean rectifier post, then run a single, short loop over to the battery. This short loop may include the fuse depending on your fuse polarity preference. If you've installed a modern rectifier-regulator unit (such as a Tynpanium or Podtronics unit), then simply install a shiny new bolt in the vacant rectifier mounting hole and build your ground point there. You'll simply bring the modern rectifier/regulator unit's RED wire over to that same bolt. You needn't have an electrical component at the point you designate as the system ground point. It's important to remember that although the SPG is physically touching the steel frame, that is NOT the objective. The objective is to get all the "return wires" (grounds) touching each other. This is what gets all the components "singing off the same piece of music".

Remember the example given earlier of how the charging system could loose 2V and the headlamp wiring could loose another 2V, leaving the headlamp bulb operating on 4V less than planned? This is because the lighting and charging systems shared separate return paths. By bringing all the return wiring to a common point, this scenario becomes impossible.

In the future, should you add an electronic ignition or other new component, you'll simply bring the necessary ground wire to this same point. Following this practice will assure you the very best connection to both rectifier and battery power sources.

Here's a table of the typical "return" wires you'll want to collect at your "Single Point Ground". It's easy to see that the SPG is a very busy place and can, with the addition of a standard electronic ignition, have six or more wires terminated there.

Destination	Used For	Source
Headlamp Shell	Headlamp & F.Blinkers	Stock Harness (after ~1963) [c]
Tail Lamp	Tail Lamp & R.Blinkers	Stock Harness (after 1971) [c]
Battery	Charging	Stock Fuse Lead
Electronic Ignition	EI Requirement [b]	User Added
Cylinder Head [a]	EI Requirement [b]	User Added
Ignition Coil Gnd	EI Requirement [b]	User Added
Accessories	Accessories	User Added

Table 1: Required return wires

Table Notes:
a) This wire exists within the stock harness on Norton Commandos and 3-cylinder machines, but should be added when installing an electronic ignition on BSA and Triumph twins.

b) Electronic Ignitions (EI), such as the Boyer, require 3 additional ground wires, some of which may already exist in your harness. Individually check each requirement.

c) When restoring older bikes, if your harness does not include this wire then it is best for the owner to add it.

Further Comments
• It is very common to misunderstand the "frame ground" concept. Yes, the frame is indeed connected to one side of the battery, but as we've discussed, that does not mean that you can save wire by simply connecting components to the frame. Remember in the first concept how one bad connection limits the flow of electricity for the entire circuit? Well, motorcycle frames are made of steel and exposed to a great deal of water. Steel + water means rust. Rust is really good at slowing the flow of electricity. "But my frame isn't rusty, it's painted" you say. It just happens that only thing better than rust at preventing electrical flow is paint; and on a steel frame, let's face it, you either have **rust** or **paint**. Additionally, many owners find to their horror that the only thing worse than spray paint for electrical connections is powder coated paint. If your lights no longer work after having the frame powder coated, do not sand the paint off... simply add return wires.

• You might ask, if the frame is such a terrible electrical conductor, why then is the battery connected to the frame on the latest motorcycles and cars? The answer is simple, but has nothing to do with lighting or charging. You'll remember that all electrical devices have a feed and a return connection. This also applies to spark plugs. The spark plug feed is through the spark plug wire, but the return is through the cylinder head, engine and frame, back into the harness. Without a frame connection the spark pugs simply wouldn't fire reliably. This is why EI require a return wire to the rocker boxes!

• Keep in mind that these return wires only work as well as the quality of their connections at both ends. After building up your system ground point, it's a good thing to trace the wire back its start and research the quality of the connection at the other end. Due to the severe vibration, water intrusion, high heat and oil common to motorcycles, if there is any doubt, then soldered connections, protected by heat shrink tubing, are always preferable.

Summation
It's important to realize that just like the transistor, automotive "grounding" is a technology that has grown tremendously over the last 30-40 years. If you own a classic British motorcycle it's often very easy to understand the need to add the latest electronic ignition and a modern transistorized charging control unit to update the electronics. It should be equally obvious then to understand that these transistorized components also require the incorporation of the latest grounding technology to deliver their optimal performance.

Hope this helps! 

RF Whatley
Rodi British Bikes