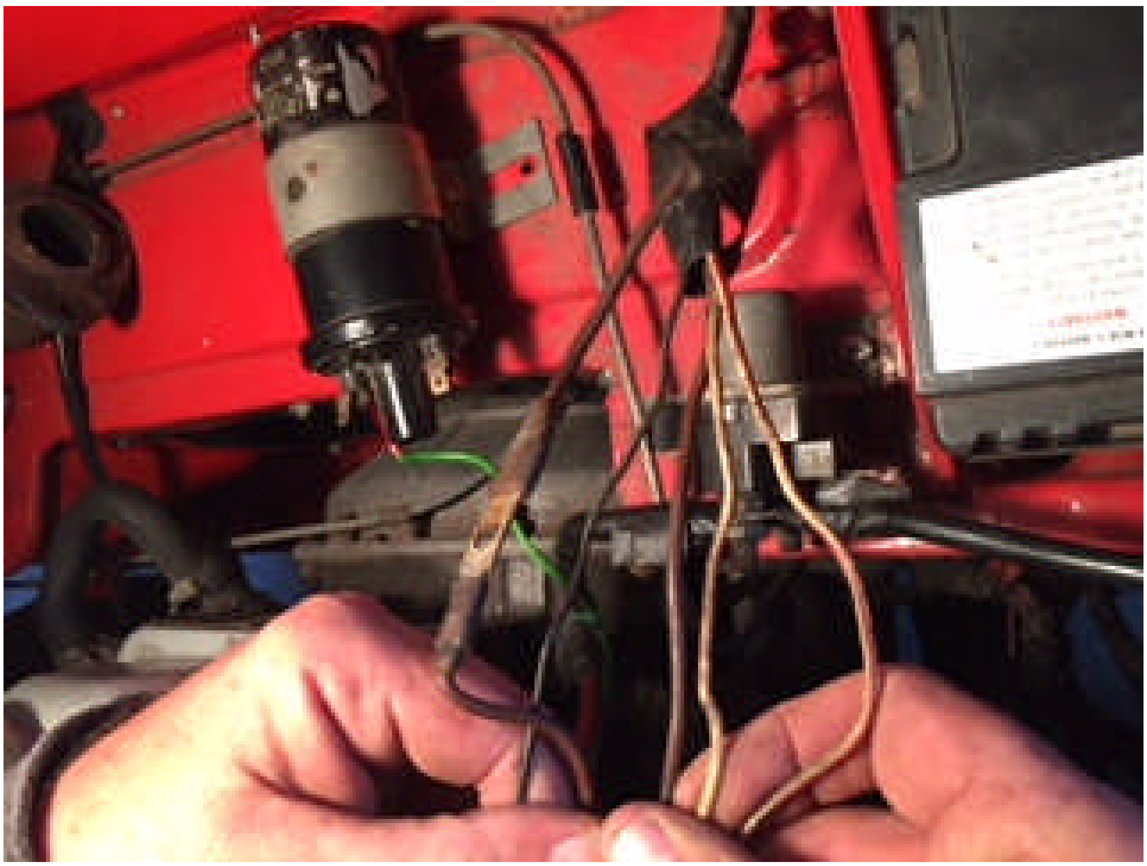
A Gentleman's guide To Basic electrical wiring in classic British cars



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INTRODUCTION:

This document is not going to be "the be-all and end-all" of electrical references but rather sets out to provide some very basic information on electricity and car electrical systems. There are plenty of other books out there if you want to find out more. One that I find particularly good is "Classic British car electrical systems" by Rick Astley but there are quite a few others out there.. If you want to know more after reading this guide, try to beg, borrow or buy a copy. Or find another similar book in a library.

SAFETY:

Most books will tell you that you should disconnect the battery. This is a good idea if you are working round the engine bay or behind the dashboard. This does mean that the battery has to be re-connected to test the results of your work. Not a useful suggestion if all you are doing is checking for voltage at various points or simply changing a bulb.
So if there is any possibility of shorting out the battery as part of your work, then disconnect that battery. Burnt-out looms and switches can be embarrassing, not to mention expensive.

Any metal object can create a short circuit and this is going to generate a lot of heat. "Metal objects" include tools, wedding rings and metal-cased watches/straps etc. Seriously consider removing jewelry before doing any electrical work.

Electricity can "bite". Coils, aka "inductors", which includes solenoids and relays, store energy magnetically and when power is removed from them, fairly high voltages can be generated. Typically about 200V at the 12V terminal of an ignition coil. This probably won't kill you but why take the chance? Disconnect coils and solenoids with power off.

DISCONNECTING THE BATTERY;

Always disconnect the earth (chassis) side of the battery first. If the spanner you are using should touch the bodywork then no harm is done. If you disconnect the "live" connection and the spanner contacts the bodywork then you will get a significant spark that potentially could cause damage to the spanner, you or the bodywork. Or all three.

TOOLS REQUIRED:

For the most part, standard screwdrivers and spanners do what is required when working on automotive electrics. A crimping tool for fitting terminals to the wires is required if you are (re-)making connections. A multimeter can be very handy to measure Volts and Amps and they all have resistance ranges which can measure resistance (Ohms).
One of the most useful tools when working on car wiring is a low-power lamp with a couple of wires attached. Crocodile (spring-loaded) clips on the ends of the leads are particularly useful. These allow you to connect this test lamp to

the wiring while keeping your hands free for other work. The test lamp provides a quick go/no-go test for Voltage. Use a dashboard illumination lamp or low power idiot-light warning lamp for this.
A pen(cil) and paper are useful to note terminal numbers and wire colours to them.
Access to soldering irons may be required.
Additional tools such as short and long lengths of wire, each with clips on the end, (jumper leads) can be very useful to (carefully) bypass switches or long runs of wire.

VERY BASIC ELECTRICITY:

Electricity behaves similarly to water or compressed air supplies. Early experimenters considered electricity a "fluid".

A battery stores charge like a tank stores water or air. Volts measure the force, or pressure, available to push the electricity round a circuit. Just like pressure pushing water or air through a pipe. Wires have resistance, like headloss or pressure-drop in pipes, and switches are like valves turning the current (flow) off and on. The biggest difference is that electricity needs a return path provided to complete the circuit, where water relies on the sun to do the job and used air returns to the atmosphere.

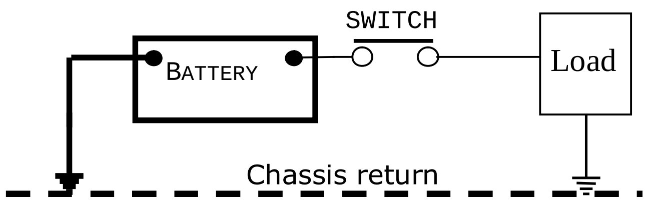
Here is a list of similar terms and items between the three:

Table 1: Similarities between different power systems

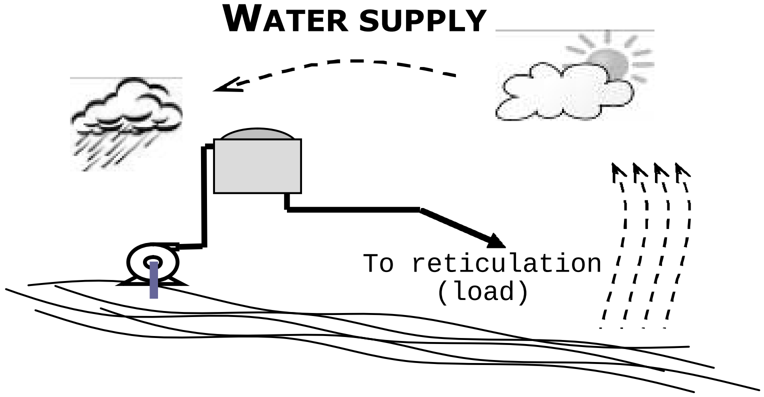
ELECTRICITY	WATER	AIR
Voltage	Head/pressure	pressure
Current	Water flow	Air flow
Resistance	Head loss	Pressure drop
Battery	reservoir	Air tank/pressure vessel
Generator/Alternator	Sun → rain/river pump	compressor
Chassis/earth	ground	atmosphere
switch	valve	valve
diode	Non-return valve	Non-return valve
load	Water used	Air tool
Open-circuit	Blocked pipe	Blocked pipe
Short-circuit	Water leak	Air leak

Sketches below show circuits for each of electrical, water and compressed-air systems. Dashed lines show return paths. For direct current electricity, the type we are interested in here, all flows are in one direction. Electrical systems return path is the chassis in most automobiles.

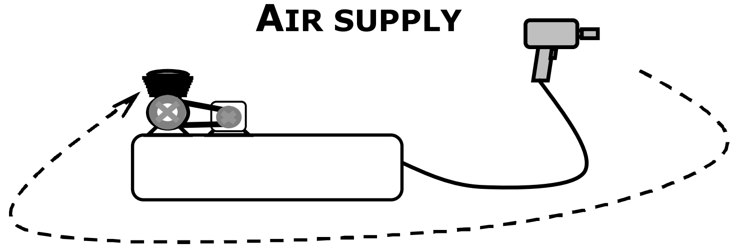
ELECTRICITY (DC)



WATER SUPPLY



AIR SUPPLY



BORING BITS:

Before proceeding, here is a glossary of terms that are used in this document to describe electrical quantities and components.

Accessory functions – as used here, refers to all switched circuits that are not essential to the running of the car’s engine. Generally supplied by green wires with or without a colour stripe. Basically everything except ignition system and electric fuel pump if fitted.

Bulb/Lamp/Light – Bulb and lamp mean the thing that actually produces light. Light is used to refer to the bulb, bulb holder and associated bits.

Circuit – wire from one terminal of the battery to something else that does something useful and back to the other battery terminal. A wiring diagram shows all the circuits in the vehicle. As used here, a circuit performs a single task on the vehicle. In cars, the return connection to the battery is normally via the chassis and bodywork.

Connector – Connects one wire to another or a thing, such as a motor or switch. These come in several types. If the connector is round it is called a "bullet" connector. If it is flat, it is referred to as a spade or blade connector.

Current – measured in Amps (A), but usually represented by "I", and measures the amount of current flowing in a circuit. This can range from 1/10 A for a dashboard light to several hundred Amps for the starter motor. Even higher if a spanner is dropped across the battery terminals.

Load – as used here refers to the item, or group of items, that draw current from the battery. Lamps, motors and horns are the usual loads found in cars. The load may be large, or high, such as a starter motor, or low as in a warning light (aka "idiot light") and may include several components such as switches. Load in a lighting circuit will often contain more than one bulb.

Resistance – measured in Ohms. A quality of all electrical bits and it absorbs voltage. When it's intentional it's fine, e.g. light bulbs, resistance wire (used in wiring to ballasted ignition coils instead of a separate ballast resistor), electric motors etc. Unintentional resistance is bad. Using too small a diameter wire or a bad joint in wire or at terminals will increase resistance in a circuit. This is why all wires are not the same physical size. Using too small a wire can cause the wire to overheat damaging the insulation.

For those who wish to know, the relationship between Volts, Amps and Resistance is "V=IR" ("R" is the resistance in Ohms, "I" is current in Amps). The Greek letter omega (**Ω**) is used to indicate Ohms in some circuit diagrams. So if we have a small wire of 0.2 Ohms carrying a current of 1 amp the voltage drop over the length of that wire is 0.2 Volts or hardly worth worrying about. A current of 10 amps passed through the same wire produces a voltage drop of 2 Volts. That's 2 Volts less "pressure" to run whatever load is connected. Since larger diameter wires have less resistance, these are used for heavier loads. Most of our cars will use at least 5 different wire sizes – including starter and battery cables. If adding things, such as electric radiator fans or driving lights to a vehicle then use a large wire for the main power to it. Too small a wire will run hot and if bound up with other cables in a loom can overheat.

Terminal – the point on a switch, light assembly, horn etc where a wire terminates (connects).

Volts – are a measure of the force (pressure) pushing the current through a circuit.

Watts – the unit of power consumed. In a DC circuit, power is the product of Volts and Amps:
Watts (W) = VI
Re-cast as W/V = I is quite useful. A 12V, 21W lamp will draw 21/12 or 1.75A. That's the current that should flow when the lamp is lit. If 1.7 – 1.8 Amps is what you measure then the circuit is good.

ELECTRICITY – WHAT IS IT?

Electricity is all about the flow of electrons and comes in several flavours which are:

Static Electricity – Caused by friction and is what gives you a bit of a bite as you get out of the car on a dry day.

Voltage here is measured in tens of kilovolts or a similar voltage to that which provides the spark in an ignition system of a petrol engine. A more extreme example of static electricity is called "lightning" and you don't want to mess with that!

Pressure Electricity – or piezoelectricity, is generated by applying pressure to certain materials. Most commonly encountered as the ignitor on the barbeque.

Current electricity which comes in two forms:

Alternating Current (AC) – is the type of electricity that is supplied to your house. This requires that a circuit, or loop, is connected across the supply before anything happens. The circuit usually contains a device that does something useful. Here electrical current moves back and forth in the circuit, the polarity changing as it does so. In New Zealand we are supplied with AC at 230V in our houses. In cars it is found only in alternators where it is converted to Direct Current before it does anything useful.

Direct Current (DC) – is the type of electricity used in a car. Here the current travels in one direction, conventionally positive terminal to negative terminal, and is stored in the battery which is recharged by the charging system; generator (sometimes called a "dynamo") or alternator. Like AC, DC also requires that a circuit is present before it does anything useful.

Generally cars operate at six or twelve volts. There are few cars on the road that run at six volts any longer, a majority of, formerly, six volt cars, have been converted to twelve volt systems. It really doesn't make much difference whether the system is six Volt, twelve Volt or twenty four Volt (large commercial vehicles – trucks). The way DC works is the same but you need to make sure lamps, motors etc are correct for the car voltage.

Car electrics overview:

As noted above, car electrics use Direct Current, commonly abbreviated as “DC” or “dc”. This means that current is considered to flow from the positive battery terminal to the negative terminal and does something useful in the process. Things that can interfere with this current flow are broken/disconnected wires, poor joints or failed circuit elements such as fuses, broken lamp filaments (aka “blown bulb”) or worn brushes in motors to name some common faults.

If the wiring has been added to, or changed by a previous owner, then a wiring diagram for your car is worth having. It can greatly assist with fault diagnoses.

Chassis (or earth) polarity:

Car electrics are described as “positive” or “negative” earth (or chassis). This tells you which battery terminal is connected to the chassis and/or bodywork. Battery terminals, positive (+) or negative (-) are labeled on the battery case and close inspection will show that one of the battery posts (terminals) is larger.

You need to know what polarity your chassis is. Things like radios, alternators and tachometers will not work and will be damaged if connected with positive and negative terminals reversed. On the other hand, horns and incandescent lamps aren’t bothered by polarity whereas LED lamps won’t be damaged but won’t work. Some motors aren’t bothered by polarity either, though some may run backwards, depending on motor type.

Some people will tell you if a car has an alternator to charge the battery, then the car is negative earth. This is not 100% correct. Austin/Morris cars, possibly others, in the early 1960s were fitted with positive earth alternators and some of these alternators may have been used in charging system upgrades.

CIRCUIT CONFIGURATION:

Two basic configurations of batteries, switches and loads are found in car wiring. These types are supply-side and earth-side switching. Both types are found in cars. Most exterior lights, some motors (e.g. starter motor) are invariably live-side switched. Warning lamps, interior lights and wiper motors are typically earth-side switched.

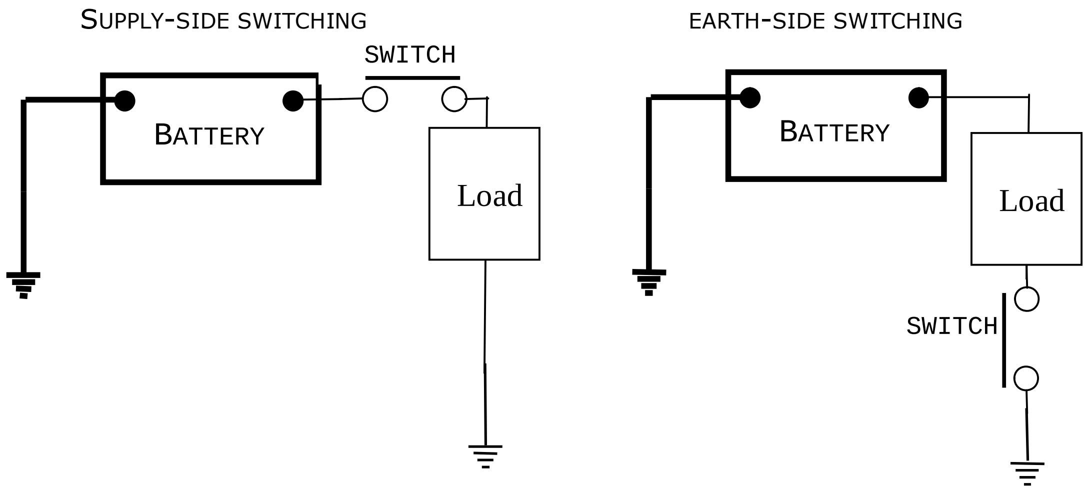


Fig. 1: Switching configurations

Earth-side switching has a lot of advantages. If a switch or wiring shorts out then the load, such as an interior light, comes on and is hard to miss. Fuses don't blow and wiring doesn't burn out. From a manufacturing point of view it can save a significant amount of wire,

Reading an accurate wiring diagram for the vehicle of interest will tell you how a particular circuit is switched. This is essential to know when trying to locate faults.

RELAYS:

In fig. 2 we see relays in a circuit. A relay is a device to allow a small current to control a much larger one. This is achieved with a low-power electromagnet, or coil, which operates a switch whose contacts may be capable of passing many Amps. Relays are frequently used to control high-current circuits such as lighting, cooling fans and horns. A starter solenoid is a type of relay. As a general rule, a relay has an electrical input and electrical output. Most time-delay controls are electronic and drive sensitive internal relays to control the connected load. Solenoids generally have an electrical input and a mechanical output such as an overdrive solenoid (which may also be controlled by a relay in circuit) and electric door lock actuators (though modern cars tend to use a small motor for this).

Relay coils can fail, preventing the relay from responding to applied voltage. If relay contacts are too light for the load they often fail open but can sometimes fail closed if the switched current is too great. If a relay is to be replaced, make sure the replacement has the same, or greater, current rated contacts as the unit being replaced.

Relays can be configured for earth-side or supply-side control switching as shown in fig. 2 below. For supply-side switched configurations, the more common configuration, always ensure the relay coil supply is fed from a switched source. Some original equipment Lucas relays have three terminals with one end of the coil connected internally to the metal case. Other relays may have four or five terminals with two for the coil connection and two or three for connecting to the load.

In the earth-side switched diagram below, a dashed line shows an alternative wiring option that enables the load to be switched on at any time irrespective of the ignition switch position. This is often used for horn or main beam flash relays but should be used with caution.

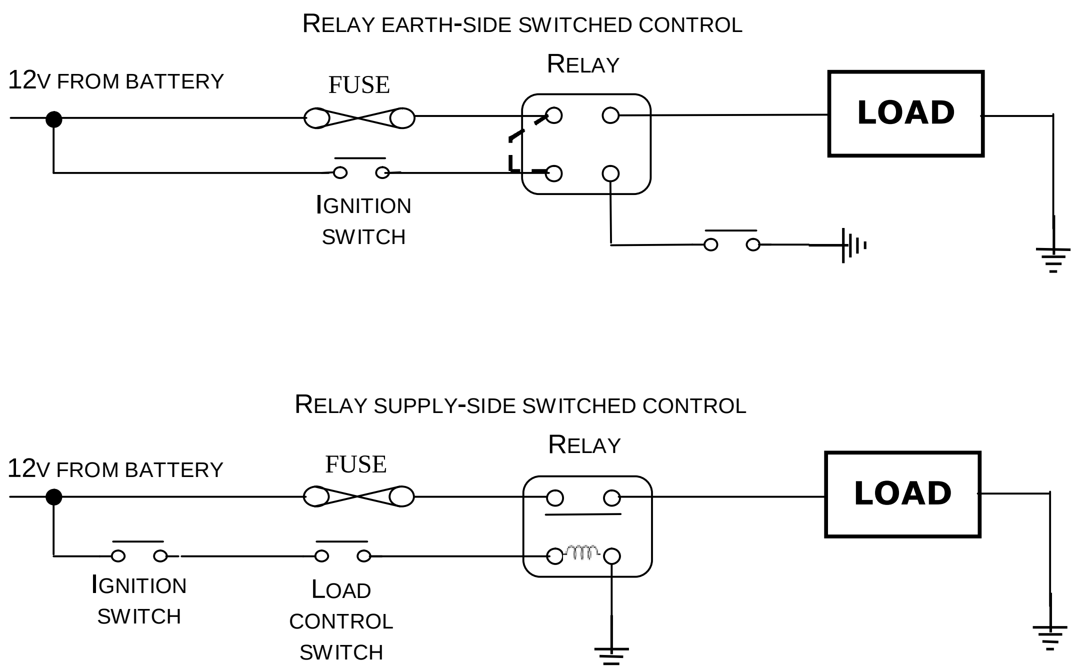


Fig. 2: Relay switch configurations

CAR WIRING COLOUR CODES:

One of the first things that you notice about the car wiring itself is a lot of wires of different sizes with a lot of different colours. These colours (as used in most British cars) are there to identify the function of the different wires. There is a method to this madness. Since the 1940s there has been a standard for these colours in British cars and most manufacturers substantially went with the standard. The applicable standard is BS-AU7 and can readily be found on the internet. Colours used may vary from this standard due to manufacturer preferences or changes to the standard over time. Ford (England) has their own system in the 1950s to 1960s and maybe later. (Main beam wiring in an Anglia is Black/Yellow!) American and Australian cars used a different system and European cars use something else again, possibly varying by country or even by manufacturer.

Table 2: The common base colours are assigned as follows:

(CAPITAL LETTERS IN COLOUR COLUMN INDICATES THE LETTER USED TO REPRESENT THAT COLOUR IN WIRING DIAGRAMS)

COLOUR	CODE	FUNCTION (MAIN COLOUR)	EXAMPLES
Black	B	Earth/switched to earth	irrespective of chassis polarity
blUe	U	Headlamps	U/R - dipped headlights, U/W - high beam
browN	N	12V un-switched un-fused supply	N - supply from battery, N/R and N/U usually associated with charging circuits
Green	G	Ignition controlled accessories	Instruments, wiper motor, heating fan, indicators, radio… G/B - fuel tank level sender, G/U - temperature sender.
Orange	O	Later wiper circuits	
pinK	K	Ballasted ignition circuits	
Purple	P	12V un-switched, fused, supply	P, P/B, P/W, P/Y common in interior lighting and horn circuits
Red	R	Lighting	Light switch supply, side lamps R/W - instrument lighting
Slate (grey)	S	Electric window supply	
White	W	Ignition controlled circuits	Switched un-fused supply, to ignition circuit, supply to fuses. W/R - starter solenoid from ignition switch.
Yellow	Y	Overdrive, P.I., door locks	
LighT	LT (or Lt or L)	Prefix denoting a lighter shade of a colour.	

These base colours are used to supply the associated circuits. A colour stripe (a.k.a. "trace") is added which gives more detailed information.

Red with white stripe supplies dashboard lighting
Green with white stripe supplies right-hand indicator
Blue with red stripe supplies headlamp dip beam

There is a shorthand system for designating colours. It uses letters to indicate colours and a slash between letters to indicate the stripe colour when present. The format is [base colour]/[stripe colour] Thus our "red with white stripe" above becomes R/W. Upper case is normally used for colours. The only exception I can think of is where a colour such as light-green is used. This is sometimes found as "LtG" but more commonly now as "LG". (Other "light" colours have appeared more recently such as LU (light blue) and LR (light red). Most diagrams will use this shorthand but in some cases the colours may be written in full as in "BLACK-RED TRACER" in a Ford Anglia manual. (BLACK-RED is headlight dip beam here.)

Generally the first letter of the colour is used to identify it but this causes problems with Black, Blue and Brown. The solution is to use "B" for Black, "U" for blUe and "N" for browN. Also Purple is "P" and pinK is "K".

Unfortunately there is no option but to look these up or to remember them. You may also find other variants in other cars. Some European manufacturers use "L" for bLue!

In most cases these colour codes will often be printed adjacent to the lines representing wires on the wiring diagram. (But not always - see fig 3!)

Mostly they work but on the car it can sometimes be difficult to differentiate between black and Slate (a.k.a. dark grey or light black).
Also R/W is completely different to W/R. (W/R or white with red stripe is almost always the wire from the "start" position of the ignition switch to the solenoid and is a larger wire than most R/W.)

All wire has resistance but copper has one of the lowest values. Nichrome, an alloy of nickel and chromium has a fairly high resistance, so nichrome resistance wire is sometimes used in the wiring loom in lieu of a separate ballast resistor for the ignition system. Usually this wire is yellow though pink has also been reported. Worse still, this wire usually consists of a single strand and thus is not very flexible. To get around this, a multi-stranded wire is used to connect to the ignition coil and this may be white or white with pink stripe (W/K).

Also unfortunate, but understandable, is the use of different coloured wires for what looks like the same function in different car models. Taking the Triumph Herald and Spitfire cars as examples, The horns on a Herald will be wired with brown and brown/black wires where those on the Spitfire will be purple/yellow and black or, for a bit of variety, purple and purple/black like a Vitesse!. (The difference is that the Brown coloured wiring is connected direct to the battery, The Purple through a fuse. See the section on Horns (fig. 5) later in this document.

THE ELECTRICAL WIRING DIAGRAM:

To those unfamiliar with car wiring diagrams they can be quite daunting - a jumble of lines, symbols and letters possibly with the overdrive circuit as an inset at the bottom of the page (or hidden somewhere else in the service manual if you are working on the overdrive electrics). It would be a lot easier to understand if each individual circuit was on a separate page. Easier to understand but service manuals would cost more. Car wiring, particularly for the cars of interest here, is fairly simple but this collection of simple circuits on one page makes it look complex.

The standard colours used were in part due to the vehicle manufacturer as far as what functions were in what category. The Herald diagram in fig. 4 shows the accessory ignition switch position as a “radio supply connection” (5A on the diagram) and all other accessory functions are wired with white wire. There was only one fuse in the car so changes of colour at the fuse block weren’t an issue. The Vitesse and Spitfire were the first Triumph “small cars” to have a fuse block fitted and accessories were supplied from the fuse block with green wire. All 2000 saloons were fitted with several (3 or 4) fuses. The TR range had a fuse block holding 2 (TR2) or more fuses.

Sometimes fuses are in-line which can be a challenge to find even when you know they are there. A fuse block is a vast improvement over in-line fuses as it’s generally easy to locate and provides a very handy test location or point to connect that new bit of kit to.

The down side of fuses is that they can fail. Fuses are subject to repeated heating and cooling and will die as a matter of course over time, For this reason you will find that the supply to the ignition coil is always unfused in these cars.

The wiring diagram in figure 3 is that for a Triumph TR2 and it is fairly typical of older wiring diagrams. It attempts to provide information of both physical location and wiring connections in one place and really is a pain to work with. The almost impossible to follow parallel lines are gone, though even less user-friendly examples of this style can be found. Note that symbols used tend to mimic the shape of the part, in most cases.

Following that a wiring diagram for a Herald 13/60 is presented in figure 4. While some indication of physical location is provided (front of car on left), the diagram is more of a schematic nature showing how things are connected. Standardised symbols are used for some components, rather than the more literal representation of the earlier TR2 drawing. What and how wiring diagrams are drawn is dictated in-house and they vary between manufacturers and models.

While much of the wiring diagram uses symbols for some components, other items are presented in a more literal fashion. Headlamps are often drawn to look like the headlamp assembly itself. Horns are another item that is very frequently represented by something that looks like an overhead view of a horn.

Ignition and lighting switches are often drawn in a manner that closely resembles the rear view of the switch, There is a good reason for this, as these multi-position switches may have numbered terminals and these numbers will usually be added to the symbol. The ignition switch (#5) for the Herald is drawn in this manner but you have to enlarge the drawing to see the terminal numbers which defeats the purpose. The light switch terminals are also numbered, not that they can be read at the scale presented here. Sometimes you will find terminals numbers written legibly on the wiring diagram, though a detail drawing of the switch may be found elsewhere in some manuals. Record terminal connections when disconnecting cables to multiple-terminal devices.

It is common practice for wiring diagrams to show main battery and starter motor connections as a wider line.

Note: Check that any wiring diagrams you have are correct for the car. I have two copies of a Haynes manual for the Triumph 2000 range of vehicles, each manual printed at different times. They do not have a complete wiring diagram for the later cars, though this may have been corrected in any even later editions. When it comes to emission control bits and brake light warning wiring, a Stag or Mk IV Spitfire manual shows these circuits in the correct colours and configuration.

WORKING WITHOUT A WIRING DIAGRAM:

Fixing car electrics can be accomplished without the aid of a circuit diagram, provided that the colour of each wire can be determined and the wiring is standard. The secret is in the wire colours. When re-connecting electrics it’s basically a case, for original wiring, of matching the colours - most of the time. Make sure though that you positively identify the colours. Not always easy to do such as with white and white/yellow wires. That yellow tracer is almost invisible. Unfortunately PVC insulation on older wire can become discoloured, stained or simply fade in the case of older fabric covered wire.

Common sense is your best tool here. If you have just done some work, of any type, prior to noticing a fault, then check to see whether you have dislodged any connectors or damaged/broken any wires in that area. Also, testing requires the ignition switch is turned on. It pays to disconnect the ignition coil, at the coil, while doing this.

Be aware that for vehicles using the standard colours, red is ALL side/tail lamps, Red/white is ALL instrument lights, Green/red and green/white are all indicator lamps for LHS and RHS respectively. If just one light, or group of bulbs in a group are malfunctioning then the problem is almost certainly with that particular light assembly. Think about things before starting work on the electrics and you should be able to solve a lot of problems without manuals or wiring diagrams. Also bear in mind that colours may change within a circuit. On the Triumph Herald 13/60 wiring diagram in fig.4 the red wires for the side and tail lights connect to a brown/red wire behind the dash, between the light switch and the headlight stalk on the steering column. So there is no red wire at the light switch which is not what you expect. Vitesses have a mid-stream wire colour change in the main beam flash circuit where a purple wire from the fuse block changes to brown in the wiring behind the dash! Colour changes for the Herald are circled with dotted lines on the wiring diagram in fig. 4. Note the Herald N to P colour change occurs at an in-line fuse, as it should. (Earlier Herald models had no fuse in the horn circuit.) Generally when you are tracing a wire you are looking for one of the same colour at each end but plainly this is not true 100% of the time. This is why an accurate wiring diagram is real handy! Similar comments apply to other cars.

TROUBLESHOOTING ELECTRICS:

By way of example, let’s say the brake lights aren’t working.
First thing is to determine that it is **ONLY** the brake lights that are not working. If we take a early (positive-earth) Triumph 2000 as an example, brake and reverse lights and the heater motor are on the same fuse. No heater motor either? Check the fuses. (Functions assigned to each fuse vary. Later models supply fuel and temperature gauges, windscreen washer, windscreen wiper motor, rear windscreen heater, brake lights, reversing lights, indicators and heater motor from one fuse.) If several electrical items have stopped working then the fuse block is the first place to check. Fuse blocks are usually easy to find. In-line fuses? Not so much. Here a wiring diagram will assist in identifying fused grouped loads.

Have a look at the brake lights. You will possibly find a black wire connected to the chassis or body. That wire is unlikely to be the issue if it is connected, screws are tight and the connections have no sign of corrosion. (Earth connections will be discussed later.) In most cases a G/P (Green with Purple stripe) wire will be seen. This is the wire that supplies the current to operate the brake lamps. Determine the location of the brake switch. Ensure that wires are connected. If the switch is damaged or loose, it is most likely the problem. On some cars the brake light switch is a switch mounted near, and operated by, the brake pedal. Other (earlier) cars use a pressure operated switch in the brake hydraulic pipework. Check the switch terminals for voltage with the ignition on. There should be voltage present on one of the terminals. If no voltage can be detected (and this is where a test lamp is as good a tool as any) then there is a problem between the switch and the battery. If voltage is present then check the brake switch. Connect the test lamp between the terminal without voltage present and operate, or have another person operate the brakes and note whether the test lamp then lights. If it doesn’t then you may have a faulty brake switch. A short jumper lead can be used across the switch terminals to confirm a faulty switch.

If the brake switch is good then it is a wiring problem somewhere. These faults can be hard to find. Wiring looms are usually well hidden. In the absence of an acrid burning smell from a wiring loom, the problem is unlikely to be behind those trim panels. Wires and connectors seldom fail for the sheer hang of it. Connectors usually fail only where there is significant movement in the associated wiring or water causes significant corrosion. To check for a problem in wiring, disconnect the brake light connection at or near the brake light(s) and use a long jumper lead to connect the light(s) direct to the battery. The bulb(s) should light up. Reconnect lights and use the jumper lead to connect the battery to the wires at the switch. Brake lights should again light up. If successful, this proves that part of the wiring is sound.

A NOTE ABOUT FUSES:

Fuses are a small diameter wire that gets hot enough to melt if the specified current is passed through it.

As a rough guide, work out or measure what the maximum current the circuits fed by a fuse are taking. Fit (or replace) a fuse with a rating of about double that. For example, assume the headlight circuit draws 10 Amps (2 x 60W bulbs) on main beam and is the only circuit fed by a particular fuse. Fit a 20A fuse here and you should be good to go. Fitting a 15A fuse will lead to early failure through no fault of the wiring or lamps though it may take months or years. Note that if you have added new equipment to a car you have probably increased the current through a fuse and depending on the current draw of the new equipment you may need to increase the fuse rating. Added equipment can cause “early” failure of a fuse which may not actually be a wiring or fault but simply an overloaded fuse.

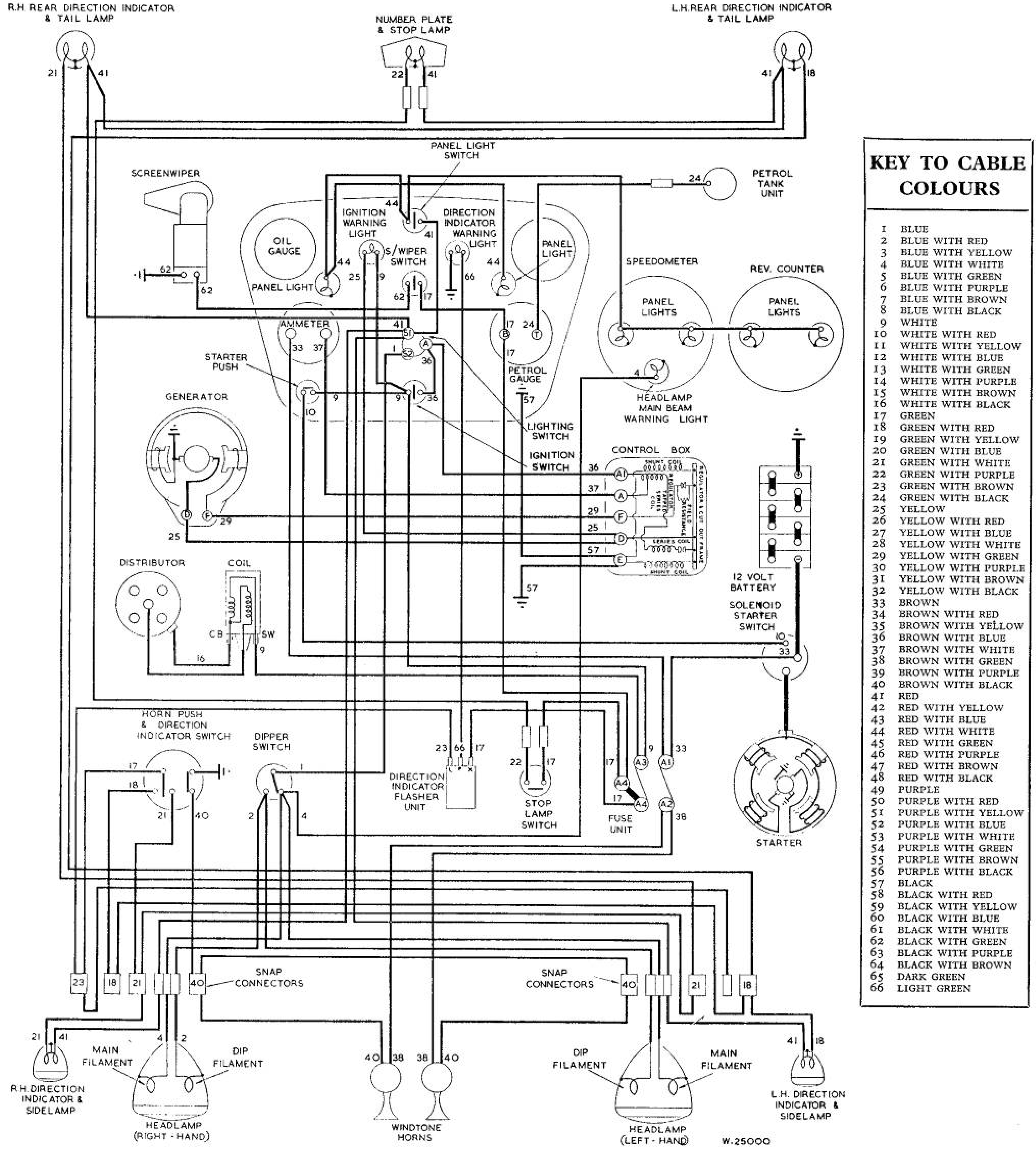


Fig. 3: Wiring diagram for a Triumph TR2 from the factory service manual. This shows an earlier style of drawing vehicle wiring diagrams. Note that the wires are marked with numbers rather than colours and the key for the wiring diagram is presented on the same page.

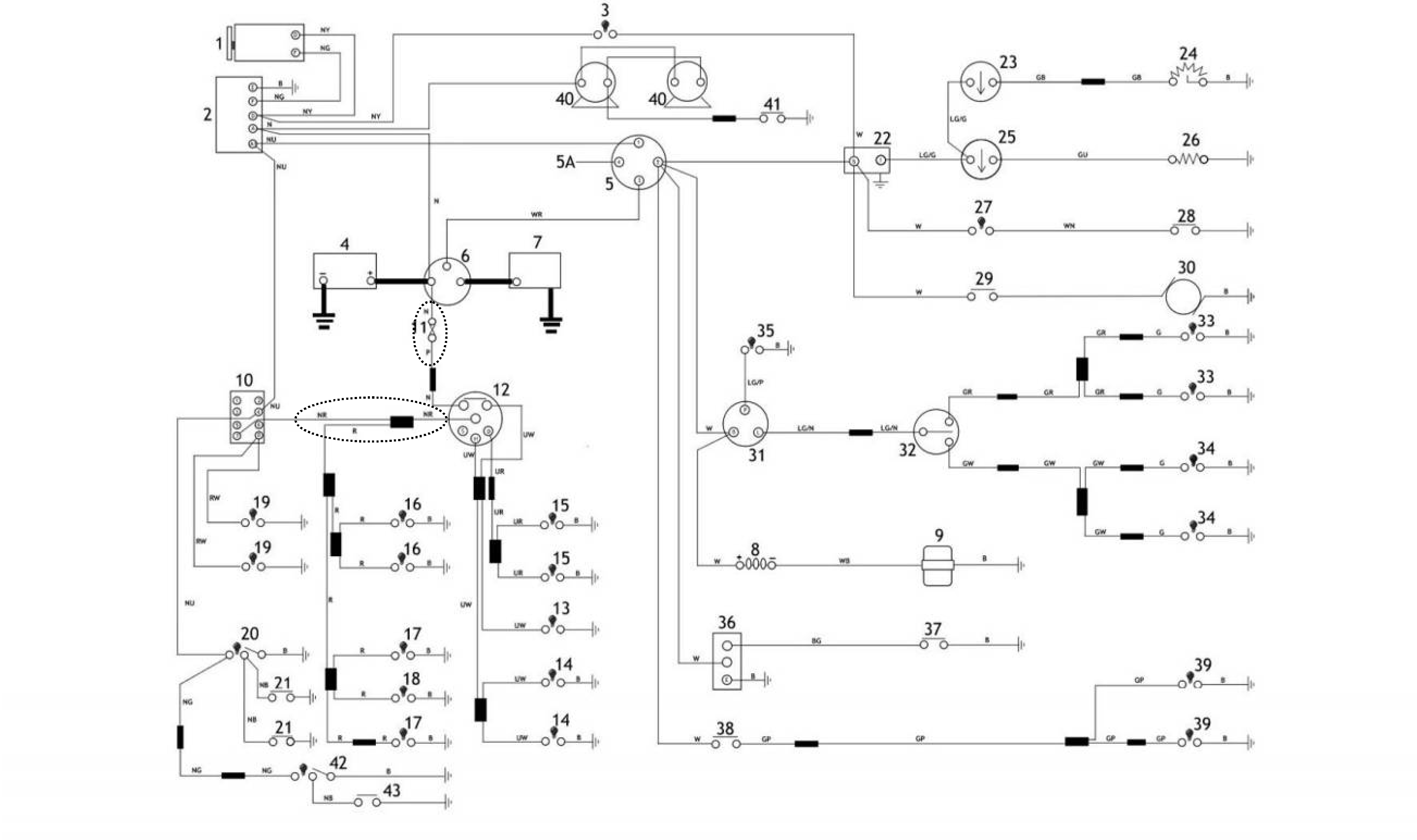


FIG 13:6 Wiring diagram, Herald Saloon, 1296cc, negative earth

Key to Fig 13:6 1 Generator 2 Control box 3 Ignition warning light 4 Battery 5 Ignition/starter switch 5A Ignition/starter switch,radio supply connector 6 Starter solenoid 7 Starter motor 8 Ignition coil 9 Ignition distributor 10 Master light switch 11 Line fuse 12 Column light switch 13 Main beam warning light 14 Main beam 15 Dip beam 16 Front parking lamp 17 Tail lamp 18 Plate illumination lamp 19 Instrument illumination 20 Facia lamp 21 Door switch 22 Voltage sabilizer 23 Fuel Indicator 24 Fuel tank unit 25 temperature indicator 26 Temperature transmitter 27 Oil pressure warning light 28 Oil pressure switch 29 Heater switch 30 Heater motor 31 Flasher unit 32 Flasher switch 33 LH flasher lamp 34 RH flasher lamp 35 Flasher warning light 36 Windscreen wiper motor 37 Windscreen wiper switch 38 Stop lampm switch 39 Stop lamp 40 Horn 41 Horn push 42 Tailgate lamp (Estate only) 43 Tailgate lamp tailgate switch (Estate only)

Fig. 4: Triumph Herald 13/60 saloon wiring diagram. Most probably from a Haynes service manual but is similar to that from other Triumph factory service manuals.

INTERPRETING THE WIRING DIAGRAM:

This is the hardest part of the job. There is no standard way of drawing components of the electrical system across time or manufacturer, though each manufacturer's diagrams tend to use the same symbols over their range of vehicles.

Dashed lines on a wiring diagram are often used to indicate optional equipment or alternate connections. Rarely these may be used to indicate a mechanical connection between two items. It should be fairly easy to figure out from the key provided with the diagram.

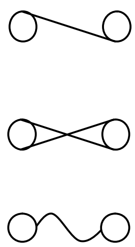
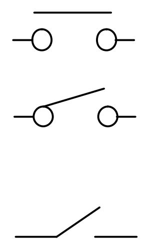
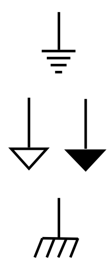
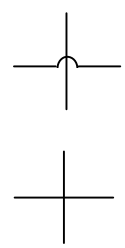
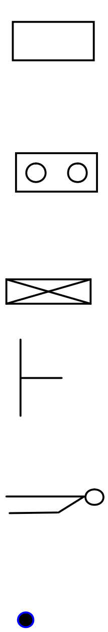
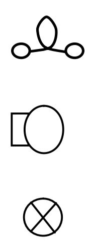
Wiring diagrams will come with a "key" identifying the components of the system and this can be seen at the bottom of the Herald diagram in figure 4. Often, as in the case of the TR2 diagram in figure 3, this will be on a separate page. Usually this key will include the colour code, as described above unless you are working on a Vauxhall Viva. The Haynes manual I have here has no wire identification codes on the schematic diagrams but has a number for each colour, colour combination and wire size on the physical wiring diagrams. Wire size can be useful but is not often provided. So "48" on one Vauxhall wiring diagram is a white wire comprising 35 strands of 0.3mm diameter conductor. On another diagram, in the same manual, "48" is a red wire with a light-green stripe comprising 14 strands of 0.012 inch diameter conductor. The correct diagram and key is essential here though a lot can be achieved simply by tracing wires and an appreciation of the basic circuit involved.

You can't blame the publishers of service manuals for this. Drawings are supplied by the vehicle manufacturer using their in-house "standards".

So the "key" really is the key. There is no guarantee that on any given manufacturer's wiring diagrams that the same component will have the same number. In the Standard-Triumph Herald/Spitfire/Vitesse factory service manual to hand, wiring diagrams have the fuel gauge as number 34 for the 1200 range Herald Saloons. It's number 36 for the estate and Courier. For the Spitfire 4 it is number 19 and number 13 for the Vitesse.

Keys work well if there are no errors and are specific to the car and model. In the Spitfire wiring diagram from this same factory service manual, the key identifies item number 8 as the horn fuse. On the diagram itself, "8" is assigned to the horn relay which is not mentioned in the key text, and no number at all to the fuse.

Table 3: Common wiring diagram symbols.

Typical symbols used on wiring diagrams. Note that standards are "in-house" standards (which may change over time) for each different manufacturer.			
	**Typical fuse symbols:** This symbol can be considered an early style. This is the more common symbol you will find. This symbol rarely found in car wiring diagrams.		**Common switch symbols:** Common switch symbol for single function ON/OFF switch. Alternative to above symbol. May indicate a manual or toggle switch. Another alternative
	**Earth/Chassis connections:** These are common symbols for these connections. You may see others but these are the most common types. Usually they are easy to spot and are often drawn with heavier lines than most of the wiring		**Wire crossings:** Either of these symbols may be used on a wiring diagram to denote wires that do not connect. This bottom symbol can be tricky. It could represent two wires crossing or four wires connecting. Look for other joint crossings and connections on the wiring diagram to determine what this one means.
1 2 3 4 5 6 	**Common connector symbols:** Symbol **1** may be coloured black and represents a physical connector of any type. Symbol **2** is occasionally found and represents a "bullet" connector. Symbol **3** represents an in-line spade connector. Symbol **4** represents a connection of any type on a wiring diagram. Symbol 5 shows two wires connecting to a terminal at a switch, bulb etc. Symbol **6** usually indicates a soldered or crimped joint within the wiring loom but may also denote any connection.	 	**Common lamp symbols:** Common symbol on Triumph wiring diagrams and many other marques. This symbol is common on BLMC (Austin, Morris etc) wiring diagrams Indicates a warning lamp in some Vauxhall wiring diagrams. Note that yet another symbol for a lamp is present on the Herald wiring diagram in fig.4. **Confusing symbols!** Junction symbol on many British car wiring diagrams. Identical to Vauxhall warning lamp above This one used to indicate a multi-pin plug's connection to a warning lamp cluster (Triumph 2000) There are bound to be more!!

HORNS – DIFFERENT WAYS OF WIRING:

Figure 5 below shows three different wiring configurations for horns as found in three Triumph cars. The Spitfire diagram is similar to early (positive earth) Triumph 2000 – latter models were wired like the later Toledo and Dolomite cars. The early Vitesse is the same as the Herald diagram though in all these cases, there are differences in wire colours. As noted earlier, the N and N/B wires on the Herald are supplied direct and un-fused from the battery whereas the P and P/B (and P/Y) wires on the Spitfire and Toledo/Dolomite are from a fused supply.

These examples are all from Triumph cars and as can be seen, identification numbers on the diagram vary with model – Horn push/switches are numbered 10 (Spitfire), 41 (Herald) and 26 for the Toledo/Dolomite.

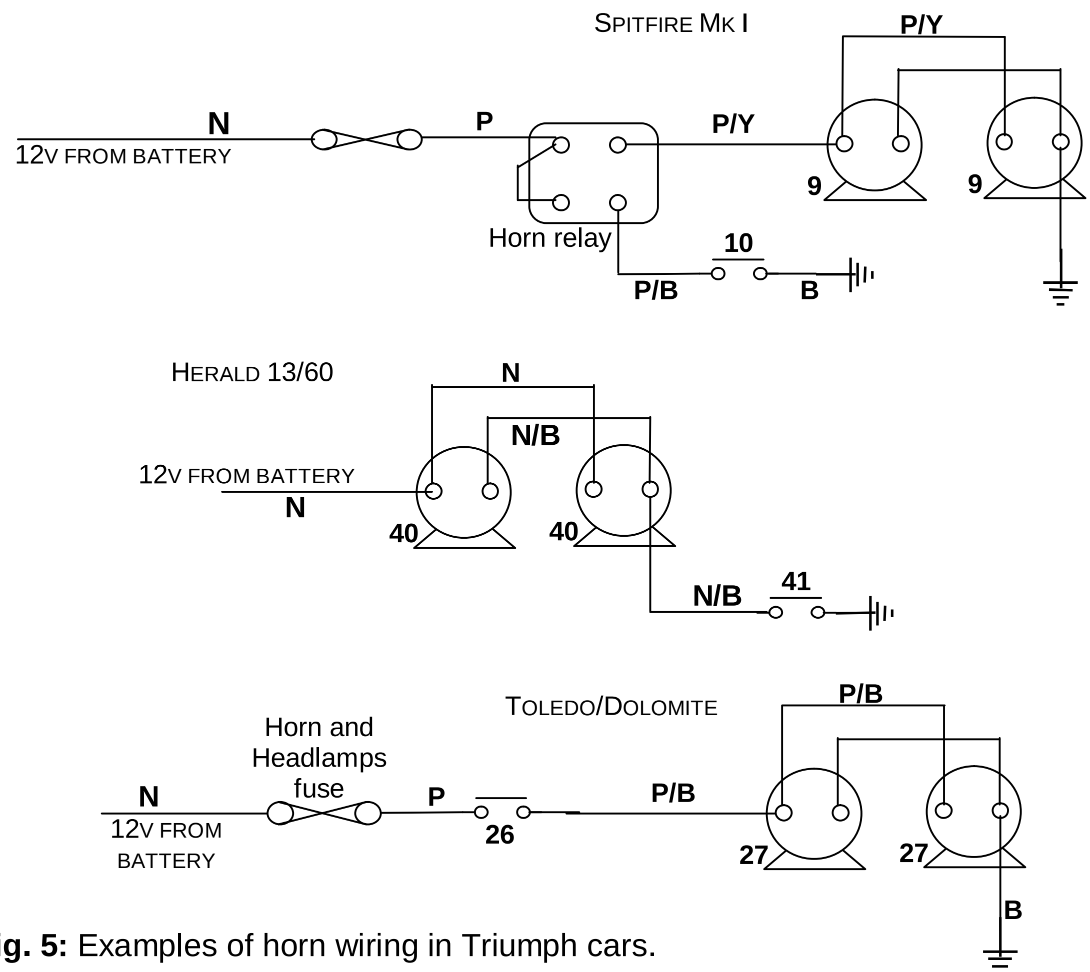


Fig. 5: Examples of horn wiring in Triumph cars.

Relays may appear drawn as above, as shown in fig.2 earlier or schematically as a coil and switch.

As can be seen from fig, 5, Spitfire and Herald horns use earth-side switching whereas the Toledo/Dolomite circuit uses a live-side switch.

STRANGE HAPPENINGS:

If your car electrics start doing strange things for no good reason, then the most likely problem is a loose or corroded joint in the circuit. One of the most common "weird" faults you will not normally see but other people will. This is a poor earth, or broken earth wire, on a tail-light assembly. An example of what poor earthing can do is described below.

Fig. 6 shows a fairly common configuration for a stop/tail light on a car. "LHS" and "RHS" denote left-hand and right-hand side of the vehicle. Here we have a very poor or missing earth connection which could be caused by a broken wire or corrosion or possibly a loose screw that forms the connection to earth. Here a broken earth connection is shown. When the lights are turned on, all lights light up but the LHS lamp will be visibly dimmer. The bulb still lights as the earth current flows through the filament of the LH brake lamp and the RH brake lamp to earth. Thicker lines show this path. Put the brakes on with the lights turned on and neither the LH brake lamp nor the LH tail lamp will work Due to the differing power (watts) of the brake lights, they may not visibly light or maybe glow faintly.
During the day, without lights turned on, current through the LH brake lamp flows through the tail lamp then through all the parallel connected side and tail (and maybe dash lamps) to earth. The LH brake lamp here also will be dim.

This sort of fault can be confirmed by measuring voltage between the metal frame of a light and earth with (in this case) the lights on. If you read several volts at this point then the earth is faulty.

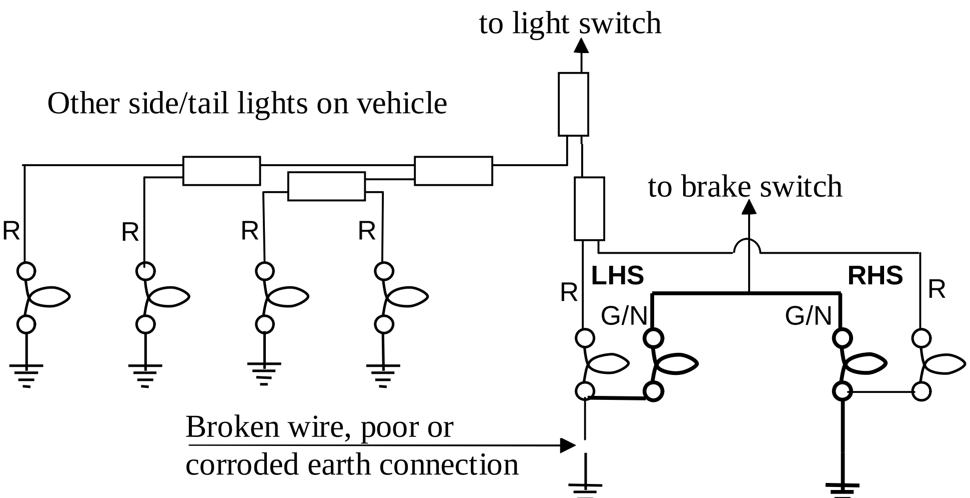


Fig. 6: Showing effect of poor or no earth on light circuit

In some vehicles a tail light assembly may include indicators as well, with a common earth connection via a wire or the screws holding the light assembly to the body. (This is a common configuration and a frequent cause of poor earths due to corrosion over time.) To add insult to injury, the indicators also will be affected in this case and the possible paths for the electric current to flow and which lights work when can be a challenge to work out.

However, it is not just lamps that are prone to earth connection faults. So if your car's electrics are exhibiting strange behaviour, such as lights coming on when you turn on a motor (which may well not run) check the associated earths.
Poor connections in the 12V supply wiring (positive for negative-earth vehicles) can also cause problems. A common one is a poor connection to the battery such that everything seems to work normally except that when you try to crank the engine all you get is "clunk" and the dash indicator lights die. This could be due to a poor joint at either battery, solenoid/starter motor terminals or a shot battery.

One thing to remember is that DC current flows in one direction in a wire **AT A TIME**.

Have a look at the diagram in fig. 7 below. A new bit of equipment has been added to the car and created an unintended connection back to the battery which is shown as a dashed line. This "extra" connection may not exist until the ignition is turned on and the new equipment first operated. Once this unintended connection has been created it just keeps on going and the dashed arrows show the current flow running "backwards" in some of the wiring. If this does, happen, check your wiring to see if you can see where this "ghost" connection is. "New" connections of this nature can easily occur when fitting relays or equipment that requires them to be fitted. There may well be no smoke to warn you of a problem but in the worst case, you turn

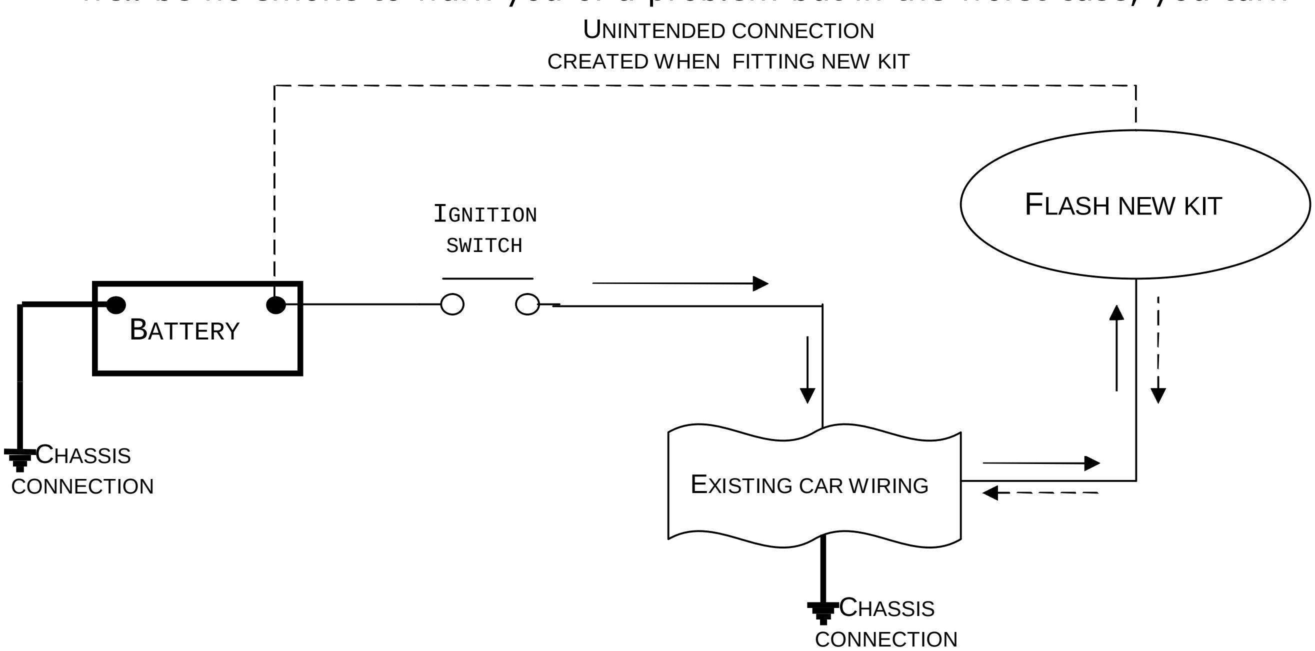


Fig. 7: Showing what can happen if you are not careful. This is one scenario

the ignition switch OFF after a test run but everything continues working! The ignition, or some other switch, has been bypassed. It may be that only one thing on the car continues to run. This sort of problem can usually be avoided by connecting at a fuse block.

At a pinch you can add a diode (electrical equivalent of a non-return valve) placed in the wiring to eliminate such unintended connections.

SUMMARY:

Working on car electrics requires a bit of thought and some understanding of how electrics work. A wiring diagram can assist in troubleshooting problems with the various circuits but it does take a bit of practice to be comfortable using one. More than anything it identifies wires by colour giving you an odds-on chance of locating the wire of interest.

Most vehicles, from any manufacturer, use the same basic circuit for the same functions though the switch details will vary. That is unless you are like Triumph (did anybody else do this?) and put a "night dimming relay" in the brake and indicator light circuits of some of the 2000 series saloons amongst other models. This did not really change the circuit beyond adding another component (relay).

So head- side- and tail- lights use the same electrical circuit on all cars. There may be more, or fewer, bulbs in some instances and the light switches may differ but the circuit is the same.

Things can get a little more complicated if there is a relay switching power to a load. In this case you effectively have two circuits for one function: the control circuit operating the relay and the relay output circuit powering the load.

Additionally you need to determine whether the circuits are supply-side or ground-switched. With few if any, exceptions, relay controlled loads are supply-side switched in the output circuit. The relay control circuit may be either.

Possibly the trickiest of the lot are wiper motors. They may be earth-side switched (common for single speed motors) or supply-side switched (all two speed motors). Most also have internal switching for self-parking. When dealing with these, a wiring diagram showing the internal wiper motor wiring is almost essential unless you are very familiar with them.

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Change log:

Date	Version	Change list
June 2020	1	Original document issue
March 2021	1.1	Minor cosmetic changes. Some minor changes to wording (grammar/typography). Corrected errors Re-ordered some sections