<u>Understanding the Electrical System</u>

Part1. Simple Electrics:

- Introduction.
- Fuses and cables.
- Batteries.
- Switches.
- Condenser.
- Ignition coils.
- Sparking plugs.
- Wire cable.
- A simple circuit.
- Wiring looms.
- Generators and alternators.
- Relays.
- Summary.

Introduction:
You have four main choices when it comes to wiring your car, namely.

1. Use the original, or a replacement, loom.

2. Use a ‘Wiring Module’ as the heart of your system and then wire each component into it.

3. Pay someone else to do it.

4. Completely rewire it yourself.

Of the four options number 1. is only really viable if you keep the electrical system fairly original. Number 2. is a bit restrictive. Number 3. can be useful, albeit expensive. If you decide on option number 4. you will know your system inside out by the time you have finished and the icing on the cake is that you will easily be able to repair or modify it at a later date.

If you intend to wire your own car you need to know a little bit about electrics (or alternatively have a knowledgeable friend). In article I am attempting to give enough information for you to wire your own car.

Note.
I covered/learnt vehicle electrics as part of my military vehicle mechanic apprenticeship during the early 1960’s. Whilst I will not pretend to have the skills of a modern-day automotive electrician it is nevertheless not too difficult to grasp the basics.

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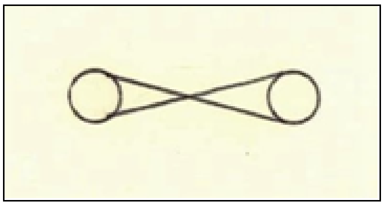
Fuses and cables:
A fuse is fitted in a circuit to protect the circuit wiring and not necessarily the component. If the fuse blows it is because either it is too low a rating or the component or its wiring circuit is faulty. Fuses are rated in amps before you can fit a correct fuse you will need to calculate its rating. There are two main elements involved. First the fuse rating should not be more than around two thirds of the cable/wire rating which it is protecting. Second the fuse should be around 1.5 times the rating of the component(s). Our car will most likely not have wind up windows or any of the other fancy stuff found on modern cars; so we will basically be considering the various lights, horn and fuel pump etc. Fuses are rated in amps and light bulbs etc. are rated in watts so we need to do a simple calculation.



Typical symbol for a fuse.

As used in my sketches.

The normal/average power of the various lights is below:
- Side lights 5 watts each.
- Tail lights 5 watts each.
- Stop lights 21 watts each.
- Indicator lights 21 watts each.
- Main beam 60/65 watts each.
- Dip beam 55 watts each.

To calculate the fuse size in amps we take the watts of the component(s) and divide it by the battery voltage which equals amps

Remember a fuse size of approximately 1.5 times the circuit amperage is ok. Note that the fuse should be rated lower than the circuit wiring. If you calculate your fuse size and it is greater than around two thirds of your wire rating then you need thicker (higher amperage rated) wire, or you will need to incorporate some relays.

Example: - When you turn on your side and tail lights you will be switching on two tail lights and two side lights each rated at 5 watts, so 20 watts in total. 20 ÷ 12 = 1.66 amps. So a 2.5-amp fuse would be suitable, but of course 2.5-amp fuses are not normally available for some types of fuses/fuse box's, you will often have to go to the next available size upwards; i.e. 3 amps.

When you move the light switch to the second position with the lights on dip or main you will be switching on two lamps of up to around 65 watts, so 130 watts in total plus 20 watts for the side and tail lights which is 150 ÷ 12 = 12.5 amps. So a 20-amp fuse would be suitable.

Now we need to consider the cable size from the fuse box to the light switch. Our worst-case scenario is two side lights plus two tail lights plus two headlamps a total of 150 watts which, doing the sums, equals 12.5 amps. So our cable needs to be above 12.5 amps. I would always go for at least double that so say 2mm squared 25-amp cable.

Now we need to decide on a fuse that protects the wire to the light switch. 12.5 amps x 1.5 = 18.75 amps; so we need a 20-amp fuse; unfortunately protecting a 25-amp cable with a 20-amp fuse is a bit too close for comfort (remember we need a fuse that is less then two thirds of the cable/wire rating), so we need a higher rated cable to the light switch. While this would work for a short time it is not a satisfactory solution and in the long term would burn out the headlamp switch contacts; so we need to have a rethink. The obvious solution is to work the headlamps with a relay or relays.

By incorporating relays in the headlamp system we can recalculate our system which is now as follows.

When we turn our light switch to the headlamp position, we are providing power to four bulbs each drawing 5 watts = 20 watts. We are also providing power to a relay which draws approximately 150 to 200 mille amps, which to all intents and purposes can be considered negligible as it is less than 0.25 amps. So again 20 watts in total = 1.66 amps and a 3-amp fuse would be suitable.

I don't like to use any cable less than 1mm squared as it always feels a bit too thin for a good connection in a pre-insulated terminal. 1mm squared thin wall PVC cable is rated at 16.5 amps which is suitable for most of the wiring on a kit car, apart from the power side of relay circuits and battery supply etc.

Note.
Nowadays I normally only buy 2mm (25amp) squared cable, it costs a tad more, 18 pence a metre, than 1mm square (16.5amp) cable, but think of the advantages; a) extra protection, b) you are only buying the majority of the cable in one main size so you have less off-cuts, and c) you can omit buying the red coloured Lucar terminals. I still need to stock Red Lucar terminals as I have a lot of 1mm squared cable left over from other jobs.

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Batteries:
Put simply a battery is a device to store electricity. It works chemically and is normally heavy as it contains a fair amount of lead. Batteries consist of a number of cells each of which is self contained. The nominal voltage of a cell is 2-volts. So a 12-volt battery will have 6 x cells (which in the good old days before sealed batteries meant 6 coloured tops). The voltage of a fully charged cell will be slightly more than 2-volts and the voltage of a discharged cell will be less than 2-volts. The range between fully charged and flat is quite small. Typically a fully charged 12-volt battery will be around 12.7 volts and a flat battery up to around 1 volt less. The useful working range of a battery is normally less than 1-volt.

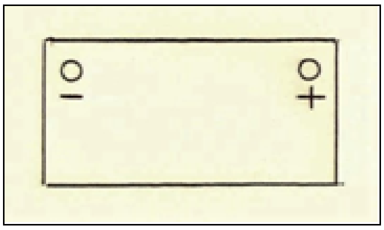
Note.
Members of my generation will recall the early 'Accumulators' (glass batteries). It was one of my jobs as a kid to walk 2-miles to the local village garage carrying the accumulator. Once there I would exchange it for our fully charged one and then walk 2-miles home again (it kept me out of mischief on a Saturday morning). Once home I fitted it in the family radio and we had news, 'Dan Dare' and music for another week. (We lived on a farm and didn't have mains electricity connected until the early 1960's).

Batteries are DC 'Direct Current' and there are two main types:

1. **Automotive batteries:** - These are designed to provide a high burst of power, such as is used to start an engine; and then to provide small amounts of power for normal running after engine start. It should be remembered that during normal use automotive batteries are being continuously charged by the generator or alternator. This keeps them in good condition and the lifespan of a well-maintained battery is typically up to 10 years or more.

2. **Service batteries: -** These are designed to give small amounts of power continuously, such as is used in campervans (or sometimes caravans etc.). In motor caravans they are only being charged when the vehicle engine is running, or in the case of caravans when being towed or connected to a mains battery charger. As a result they are often used when not being charged. A service battery is designed to be charged and discharged (as opposed to an automotive battery which apart from starting is normally only used when the vehicle engine is running or when parked at night with the lights on). Obviously, this continuous charging and discharging of a service battery at irregular intervals reduces its lifespan to normally between 4 to 6-years.

The symbol for a battery varies but is typically similar to the sketch below.



Typical symbol for a battery.

As used in my sketches.

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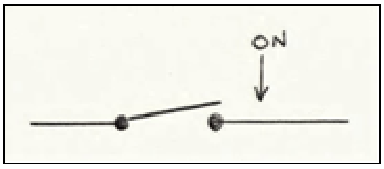
Switches:
A switch is simply a device to 'make' or 'break' an electrical circuit; i.e. to switch the electricity on or off. Switches can be 'manual' or 'automatic'. A typical use of an automatic switch would be to work the cooling fan for a vehicle radiator:

1. **Manual switch:** - Moving a lever or pressing a button will cause contacts within the switch to open or close. The contacts are normally operated by spring pressure, which gives a quick opening or closing of the contacts and reduces electrical arcing (sparking) at the contact points, and thus prolongs the life of the switch.



A simple switch.

As used in my sketches.

2. **Automatic switch: -** A simple automatic switch consists of two pieces of metal strip which have different expansion rates when subject to a heat source. The two pieces of metal are joined together (known as a 'Bi-Metallic Strip'). If we now subject the switch (the two pieces of metal) to heat, the combined metal strip will bend. Now imagine the two strips of metal are horizontal and the metal which expands most is at the bottom, as the two metal strips heat up the lower one will expand more than the upper one, which causes the strip to curve and bend up at the end. If we fit a contact point slightly above the strip when it is cold then heat will cause the strip to bend up and touch the contact and complete the circuit.

A simple automatic switch.

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Condenser:
A condenser is a small electrical component that can reduce arcing of switch contacts and also help eliminate radio interference; it works by absorbing and releasing excess current. An engine 'Distributor' is a switch that makes and breaks the circuit thousands of times a minute over many thousands of miles of usage. The condenser is normally cylindrical and fitted inside the distributor, but it can be fitted on the outside of the distributor or near the ignition coil. It is fitted in the Negative (-) circuit and absorbs/reduces the spark that occurs between the contact breaker points, when they are opened by the cam in the distributor.

Note.
Don't confuse these with the condensers that are sometimes fitted in the Positive (+) circuit. The purpose of those is to help reduce radio etc. interference.

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Ignition coils:

An ignition coil consists of two separate coils (Primary and Secondary) of wire around a central core; all of which are contained in a housing. The housing has 3 terminals consisting of a Positive (+) Negative (-) and a central HT (High Tension) terminal that provides power to the spark plug. In cars etc. this high-tension lead from the coil goes into the centre of the distributor cap from where it is distributed to the individual plug leads via the rotor arm. On a modern high-performance engine; e.g. a sports motorcycle, it is quite common to have a separate coil for each cylinder.

Whenever the ignition is switched on power is supplied from the battery to the Positive (+) terminal on the coil and electricity flows through the low resistance primary circuit (which surrounds the secondary circuit) before it passes to the negative connection on the coil. The Negative (-) terminal is attached to the CB (Contact Breaker) points in the distributor. As the distributor camshaft rotates the cam opens and closes the points (switches off and on the circuit/current flowing through the coil). When the points are opened the current in the primary coil collapses and a high voltage (in the region of 50,000 volts or more) is induced in the secondary (high tension circuit) where it is delivered to the centre of the distributer cap, down onto the rotor arm, along the rotor arm, and up into the appropriate distributer lead, where it finally produces a spark at the correct sparking plug.

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Sparking plugs:
A sparking plug is simply a device that consists of two terminals (electrodes) which are held slightly apart in the combustion chamber. When the up-coming piston squashes the fuel air mixture sufficiently a spark is timed to jump across the spark plug electrodes. This causes the air/fuel mixture to ignite and the resulting controlled explosion forces the piston down.

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Wire cable:
The various components in an electrical circuit are joined together by wire cable. Two main types of wire cable are generally available for automotive use:

1. **Single core PVC cable: -** This was used on most motor vehicles until a few years ago. It has now been mostly superseded by;

2. **Single core PVC thin wall cable: -** This has been in general use for the last few years. As insulation improved it was able to be made thinner. The main advantage to vehicle manufacturers is a reduction in cost and the external diameter of wiring looms. This type of cable will also carry more power due to the improved insulation material.

Both types are readily available in a variety of colours.

Note.
I have been a customer of 'Vehicle Wiring Products' since the late 1990's and I normally get all my electrical equipment/items from them. As an example they can supply any size of PVC or thin wall cable in any colour and any length. They will also provide made up battery cables etc. to length fitted with your choice of terminal ends. This is a 'One-Stop-Shop' for all of your electrical items.

Electrical wiring comes in a vast range of colours and there is a 'British Standard' for wiring various circuits in 'Automotive Application's.

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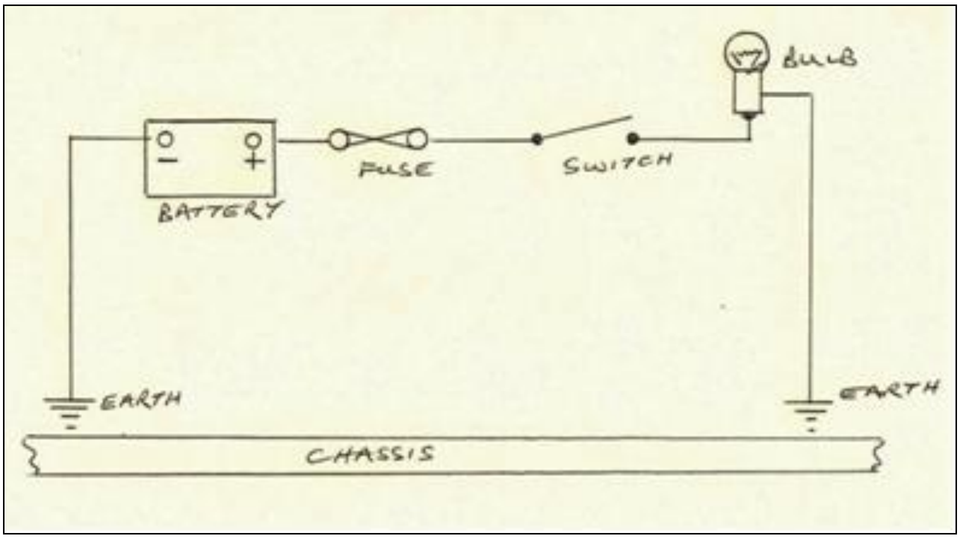
A Simple Circuit:
A simple circuit consists of a cable leading from the 'Positive' (+) terminal of the battery to a fuse. Another cable runs from the fuse to the switch. Another cable runs from the switch to an electrical component such

as a light bulb. Another cable runs from the light bulb to the chassis. Finally the last cable runs from the chassis to the 'Negative' (-) terminal of the battery.

Note.
Automotive chassis are normally made of metal which is a good conductor of electricity. By using the chassis as part of the wiring circuit an automotive manufacturer can reduce the usage of 'Earth' cable. In a wiring diagram an 'Earth' symbol normally looks like a Christmas tree, mostly upside down but I have seen them on their side. As the chassis carries a lot of Earth returns from electrical components the cable that runs from the chassis to the battery needs to be quite substantial in order to prevent it overheating.



A simple circuit.

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Wiring looms:
For neatness an automotive manufacturer wraps groups of cables together in what is called a loom. For convenience the equipment may have the loom split into a number of different sections; e.g. the ignition circuit may be a separate loom from the general wiring loom.

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Generators and alternators:
A battery is only any good when it holds a charge! If it was just used on a vehicle, it would soon go flat and electrical components (lights etc.) would stop working and in many instances the engine would stop.

Note.
Older style diesel engines (and petrol engines fitted with a magneto; e.g. lawnmowers) don't require a battery to run, only to start them. Some didn't even have a battery and just had a cranking handle, or in the case of most lawnmowers a pull cord.

In early motor vehicles the device that put electricity back into the battery was called a 'Generator' or 'Dynamo', which was like an electric motor operating in reverse; i.e. instead of using battery power to rotate it it produced electrical power when it was rotated by engine power.

Note.
By making a small change to the external wiring off a generator it will run like an electric motor when connected to a battery. In fact that is how we used to test them.

As automotive electrical components got more numerous, and complicated, vehicles needed more battery power; this resulted in the batteries being flattened as the generator was putting less charge back into the batteries than the electrical components were using. The answer was the 'Alternator' which was much more efficient than the generator and was more than capable of keeping the battery charged, even when all of the electrical components were switched on.

Note.
The exception was my mate 'Ken' who in 1972 bought a new 'Ford Cortina 1600E'. He fitted so many lights and accessories that he often ended up with a flat battery as even the alternator couldn't cope.

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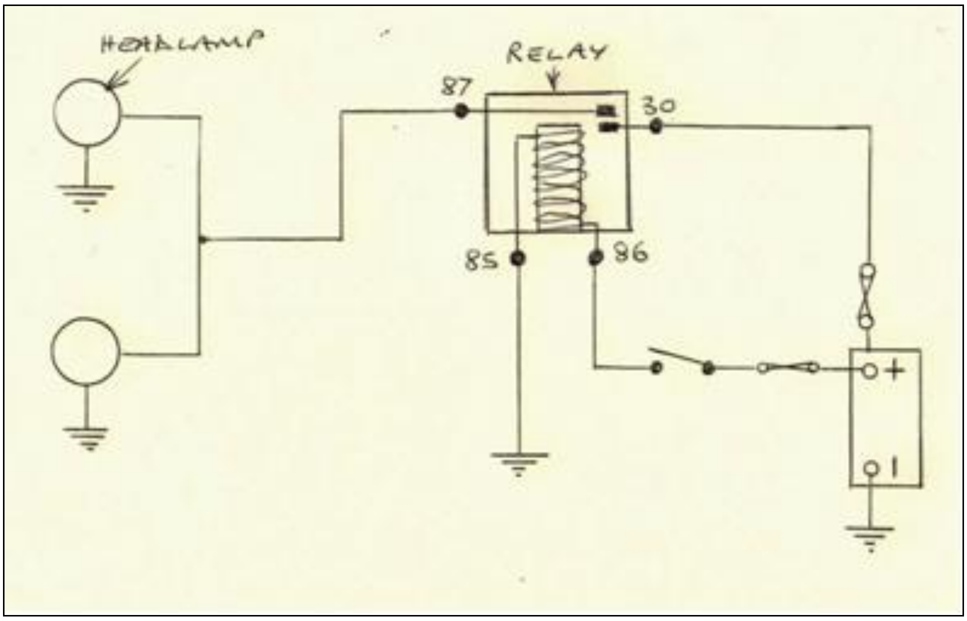
Relays:
Some components require more electricity than others. If a component needs more power, then it has to be fed by a thicker wire or the wire will get hot and possibly cause a fire. To avoid having to use thicker cables throughout the circuit the manufacturer employs a 'Relay'. The relay is an electrical switch; the switching can be done with thin cable; operating the relay with thin cable causes current to flow round an electro-magnet. This connects two internal contacts that are provided with thick cable. A typical use of a relay would be to provide the power to a pair of headlamps.



A simple circuit with a relay.

Notes.
Terminal 86 = Supply from switch (thin wire).
Terminal 30 = Supply from battery (thick wire).
Terminal 85 = Relay (switch) wire to earth (thin wire).
Terminal 87 = Supply to lights (thick wire).

When wiring a 4-way relay without an integrated diode Terminals 86 and 85 are for the switching wires. They can be wired either way round and still work but the 'DIN' Standard requires Terminal 85 to go to earth.

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Summary:
Electricity can be as complicated as you want to make it. The trick is to think of each part of the circuit separately and then later combine them into a complete circuit or wiring diagram/loom.

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Part 2. Wiring General:

- Introduction.
- Method of wiring.
- Wiring loom circuits.
- Making the connections.
- Summary.

Introduction:
In the previous chapter I discussed simple electrics; now let's look into our automotive electrical system in a little more depth. Modern day cars have an overly complicated wiring system. We are building an old-style car so keep it as simple as you can.

Some kit car manufacturers supply certain switchgear and instruments as an extra and if you bought a dashboard as part of the kit it will sometimes be pre-drilled to take the instruments and switches supplied.

If you have bought a manufacturer supplied wiring loom then fit it in accordance with any instructions.

Note.
Due to the differing requirements of owner/builders some kit car manufacturers no longer sell wiring looms and instead provide a module for you to connect yourself. Personally I think that this is a good thing! You are building your own car so why not use it as a learning process. "I like cars that can be repaired with a Swiss Army Knife, not a computer!"

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Method of Wiring:
The method I normally employ and will describe is for a '***Wired Earth Return System'***; i.e. we are not relying on the chassis to provide an earth; this **can**** make the system more reliable.

Note.
*I say **can**** make the system more reliable, rather than **will**; this is because in theory I will end up with more wires in the car which will increase the unreliability risk; but think about it! "I won't have more wires but they will be longer wires!" As long as I prevent them chafing they will be ok.*

So why would I want to fit a wired earth return system? The answer will almost certainly be subject to disagreement/controversy; in the first place some kit car manufacturers do not provide chassis earthing points as such and rely on earthing via Riv-Nuts. To me that is not a very satisfactory solution as you have no method of abrading the connection. Additionally I have a very good memory and when I covered the electrical side of my vehicle mechanic apprenticeship two things stood out. First in the early days cars generally had 6-volt batteries and could be either positive or negative earth. When manufacturers started to upgrade to 12-volt batteries (to start more powerful engines) it was found that the sparking plug terminals suffered from increased erosion. It was eventually discovered that the sparking plugs suffered less erosion with negative earth. For example VW Beetles were originally 6-volt positive earth and changed to 12-volt negative earth, MGB's built up to the end of 1967 were also positive earth. Second, problems can arise with an electrical current flowing through combinations of dissimilar metals;** in our case often steel and aluminium. I clearly remember being told that having a wired earth return would help reduce this electrolytic corrosion. So why don't manufacturers fit wired earth return systems? To me the simple answer is that by using the chassis as an earth they save a lot of money by using less wire. As mentioned elsewhere I'm only building a one-off car and I'm not worried about spending a few quid extra on more wire.

So rightly or wrongly I tend to use a wired earth return system; however we need to bear in mind that for an electrical system to work it needs a full circuit; i.e. it leaves one side of the battery and needs to meet up with the other side to complete the circuit. This means that I need to provide a heavy-duty cable from the battery negative post to the engine. Otherwise the sparking plugs wouldn't spark and the starter motor wouldn’t rotate. I will also provide a heavy-duty cable from the battery negative post to the chassis but I won’t use the chassis as an earth return.

Now I must admit that my thinking may be at odds with current beliefs and practices but to me it makes sense to have a wired earth return system!

Note.
*Have you ever followed another vehicle and seen all the rear lights go crazy when the driver in front brakes? The problem is **always** caused by a bad chassis earth on one or more rear lights.*

Postscript:
*Years ago I was a Reliant Scimitar enthusiast and I have had 4 of them. I had a friend who also had a Scimitar until one night in the early 1990’s when some arsh*le nicked his. After that I fitted three anti theft devices to my car. I started by making a bracket that was held onto the steering column (tucked up under the dashboard), with hose clips. This bracket held three switches, namely; a battery master switch and two toggle switches. The battery master switch disconnected the battery, one toggle switch shorted a wire from the Negative (- terminal) of the ignition coil to earth and the last toggle switch broke the earth in the right-hand rear light. The idea was that if anyone nicked my car the malfunctioning rear lights would attract ‘Plods’ attention, mind you what good that would do I do not know!*

The photos below show a bracket that I had fitted to three different Reliant Scimitars, the last one being a ‘Scimitar GTC SE8B Convertible’ that I owned for 23 years; the bracket was held in position on the steering column by Jubilee clips and is simply made from a piece of cut and bent aluminium angle.

Simple but effective.

The anti-theft device fitted to my Reliant Scimitar's.

As you can see it is reasonably easy to make. These modifications are incorporated in my kit car builds but I often have to find another mounting location as on some cars the steering column isn't long enough to take my homemade bracket.

The only item that needs a very heavy-duty battery cable is the starter motor. Depending on the location of your battery you could take a lower rated lead from either the starter motor or the battery positive terminal to power your electric box.

On my wiring system I have positive and negative stud/post connections mounted on my electric board. The two posts will be connected to the battery positive and negative terminals by 10mm squared (70amps), cable. I do not have suitable tools for these end connections so I got Vehicle Wiring Products to make them along with my main battery cables. For the purposes of testing I fitted 50-amp slave cables.

The positive post connects to two independent 30-amp fusible links via 50-amp cable. One fusible link supplies power to the permanently live side of the fuse box. The other provides power to a 70-amp relay that passes power to the ignition-controlled side of the fuse box when the ignition key is turned to the second position.

The main positive and negative leads; from the battery to the master switch and on to the starter motor and earthing points on the gearbox and chassis are 40mm squared (300 amps) cable.

Before you can order/purchase these heavy-duty cables you will need to determine the location of your battery so you can calculate the length. These cables are very important and my advice is to order them specially to suit your car.

A suitable starting point for making/completing the car electrics is the dashboard! This is because our switches and instruments will control how our wiring system develops. If you have worked on cars from almost any era you will have noticed that a manufacturer makes extensive use of multi-plugs to connect the various parts of the harness together. You can buy these latest multi-plugs, male and female pins/connections and the necessary fitting tools at a reasonable price. Alternatively you could use the so-called chocolate blocks or terminal blocks. Automotive manufacturers tend not to use chocolate type terminal blocks these days, but they were very common years ago. I use 4-way or 8-way Lucar terminal blocks for most of my connections in the electric box.

As discussed in ***'Chapter 20. Simple Electrics'*** a simple circuit consists of; a battery, supply and return, positive and negative wires, fuses, an electrical component and finally a switch.

There are normally 2 x places to put a switch; i.e. in the positive or negative wire. Horn switches were almost always placed on the negative side of the electrical component (horn). Some military automotive electricians (of my era) advocate that the switches should be put in the negative wire whenever possible; the main reason being that the switch lasts longer.

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Wiring loom circuits:
Wiring a complete car can seem a little daunting at first. The secret is to draw out the circuits separately. If unsure then obtain a wiring manual for an old car (pre-1970) about £1.00 from a car boot sale, and copy the circuit you need. Then wire each circuit up and after checking it all works combine the wires in a neat loom. As an example, you will need the following circuits.

- Dashboard.
- Ignition supply to fuse box.
- Ignition supply to starter motor and engine wiring.
- Charging system.
- Lighting circuits; side and tail, indicator, stop, dip and main beam.
- Indicator and 4-way flasher circuits.
- Warning light circuits.
- Horn(s) circuit.

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Making the connections:
'Pre-Insulated Crimped Terminals' versus 'Crimped and Soldered Terminals'? If you ask a number of electricians they will all come up with different replies. Consider the following though:

- Soldered terminals are very rarely used in the aviation industry (or maybe I should say that they were very rarely used when I worked in aviation).
- A soldered joint is only as good as the person who makes it.

Notes.
If you use good quality terminals and crimping pliers according to the manufacturer's instructions; i.e. use the correct size terminal to match the cable/wire size and crimp with the correct part of the pliers then the joint is foolproof.

Having said that, there is a place for a soldered connection; namely to strengthen the wires where they are secured by a screw connection without a pre insulated terminal, or for increasing the diameter of a very thin wire, but remember, you can buy Lucar style pre-insulated terminals, called 'pins' that work admirably in such situations.

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Summary:
In the previous chapters I have tried to demonstrate/explain that automotive electrics is not that complicated on older style vehicles.

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Part 3. Wiring a Kit Car:

- Introduction.
- Wiring modules.
- Electric panels.
- Wiring Mungo.
- Summary.

Introduction:
When it comes to wiring a kit car etc. yourself there are four main options, namely:

1. Use a manufacturer's loom.

2. Cut and shut the original loom.

3. Do your own wiring using a commercial wiring module; or

4. Design and fit your own wiring system.

Carried out correctly either of these options is acceptable. In order of simplicity it probably follows the order I have listed them in.

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Wiring modules:
The wiring modules are very good but I like to be in charge of my own destiny and be able to see a complete circuit rather than try and trace wires that are disappearing into a plastic box or module.
The heart of my electrical systems is an electrical control panel made out of insulated material.

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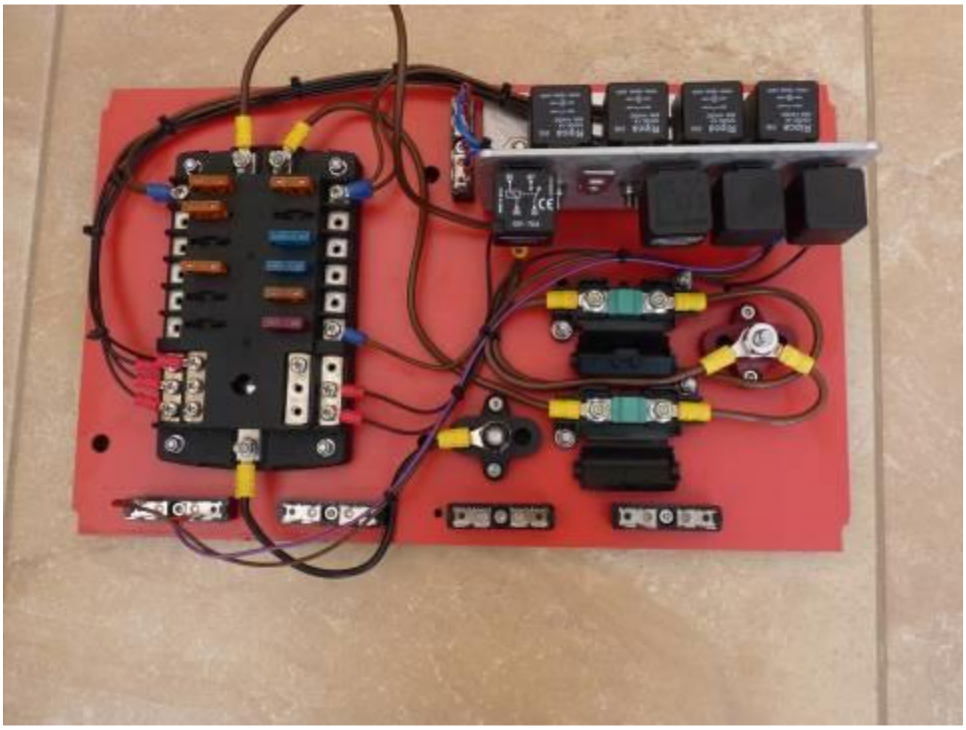
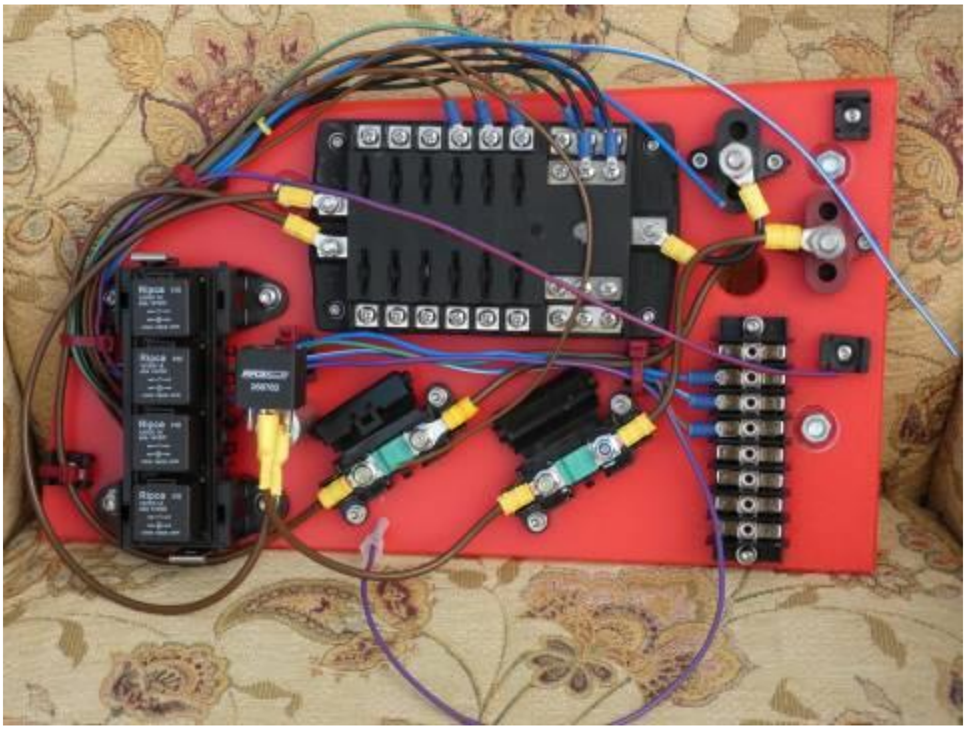
Electric panels:
Instead of using a wiring module I make my own electric panels. The one shown in the first photo is one I made for Kermit my Aero Merlin Cyclecar; this lays flat in an aluminium box. The second photo shows the one for Mungo my Lomax 224 which I am completely restoring, (Rufus my NGTA which I am restoring alongside Mungo will get a similar one).



Kermit's electric panel.

Mungo's electric panel.



Ditto.

Mungo's electric panel is a bit on the small side as it is going into the confined area on the inner vertical bulkhead above the passenger's legs (away from the elements). It is made out of a 12mm thick plastic chopping board and all the main items are on it. Of course you don't have to mount everything on a board (and you could use a more subdued colour, like black) but having them on a board means I can carry out a lot of my wiring in/at the comfort of the conservatory table.

Power enters the board via a Red negative post which is fed from a battery master switch. Circuits are completed via a Black negative post which is connected directly to the battery and the negative circuits of the fuse box and relays etc.

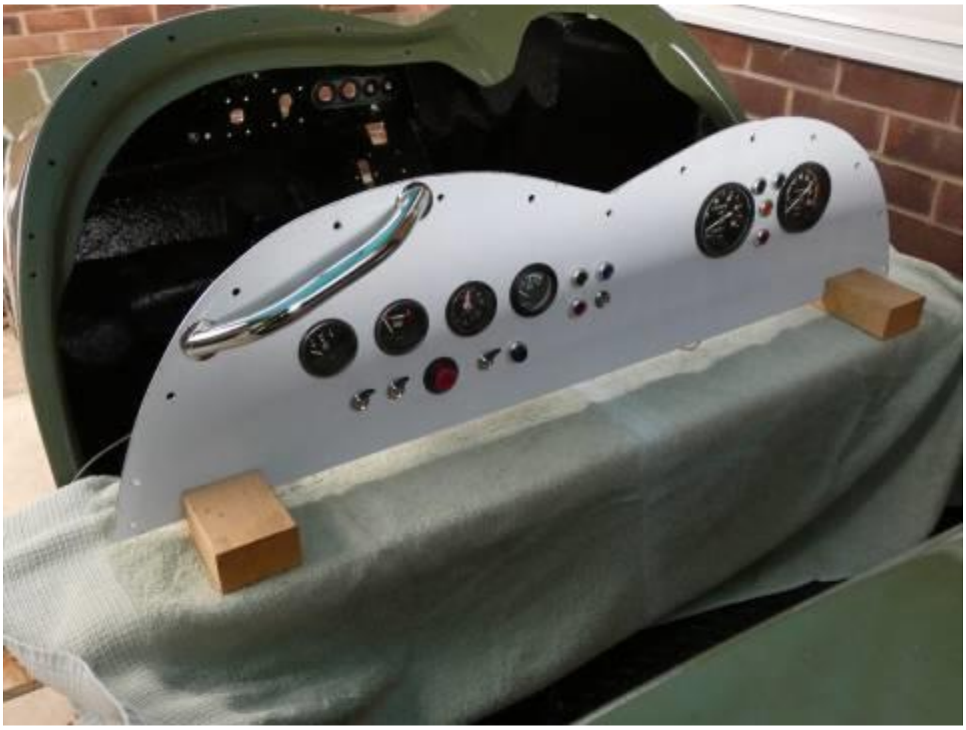
The 12-way fuse box is split into two 6-ways. One side is live and is fed from the positive post via a fusible link when the battery master switch is switched on. This powers the 4-way flashers, horn, sidelights and headlamp flashers etc. The other side is fed by a fusible link which feeds a 70-amp relay. It is only live when the ignition is switched on providing power to switch the relay. This powers the dip beam headlamps, main beam headlamps, and fuel pump switch etc.

The electric panel sends and receives harnesses as appropriate to and from the instruments, switches, ignition switch/steering lock, engine, front left lights, front right lights, rear lights and fuel tank etc. The harness for the rear lights is good quality 10-core trailer cable, the other harnesses are home made.

To complete it the electric panel will be wired to short pigtails; the pigtails will be connected to the various harnesses by 'multi-Connectors' (plugs and sockets) from Vehicle Wiring Products. These are reasonably priced; e.g. a 1-way is £0.60 going through the range to an 11-way at £4.04. The special terminal crimping pliers are £8.95 and a set of 'Unlatching' (Terminal Extraction) Tools is £20.52. Unless you do a lot of wiring you don't really need the extraction tools. A decent pair of crimping pliers for Lucar style pre-insulated terminals will set you back another £20 or so. All prices are subject to VAT.

If you are not used to using these types of Lucar terminal crimping pliers then you need to be aware that once the crimping process has started the crimp has to be fully made before the pliers release their grip. This ensures a uniform clamping/crimping pressure.

My dashboard harnesses are 500mm longer than needed, the surplus being coiled out of the way. Mungo's dashboard is a single piece and to work behind the dashboard without grovelling upside down it is simply unbolted and moved rearwards 500mm and stood on a board that spans the car. In the photo the bottom edge of the dashboard is sitting in saw cuts in two wooden blocks which holds it nice and secure. If I want to work on the electrical panel I have the option of hanging the dashboard from a carport roof beam so it is above the fibreglass scuttle.



Don't grovel about under the dashboard.

Again dashboards can be made and tested against the electric panel in the comfort of the conservatory.

I've made quite a few of these electric panels over the years. It is not as easy perhaps as using a current day module, but as I mentioned at the beginning, I like to do my own thing and once you have made one you will know your electrical system inside out! The one for Rufus may look less cluttered as I will hopefully have room for a larger electrical panel.

The photo below shows left to right; wire stripping pliers, multi connector crimping pliers, unlatching tools and Lucar terminal crimping pliers.

Useful items to have.

The three different terminal colours represent wire/cable core size; Red is suitable for 0.65 to 1.5mm squared, Blue 1.5 to 2.5mm squared and Yellow 3 to 6mm squared. Terminals vary in price but are approximately £3.50 for 50.

If I need connections larger than the Yellow; e.g. main battery cables to the battery master switch, engine, chassis and my electric panel; I get them made up by Vehicle Wiring Products as it is not worth paying in the region of £100 for the special tools to make the odd battery cable.

Tip: - *Sometimes the female Lucar terminals can be a very tight fit, so much so that trying to push them on a switch terminal etc. can bend the switch terminal. I avoid this by keeping a male Lucar terminal on a short (50mm) length of coloured cable (so I can spot it more easily after laying it down). I trial push this into the ends of all female terminals before I fit them to the switch etc.*

Tip: - *Don't over twist the wire; just turn the end to straighten the strands sufficiently to enter the Lucar terminal.*

Tip: - *When crimping line up the terminal slot/slit so it is being pressed on by the 'anvil' or the 'former' of the crimping pliers.*

***

Wiring Mungo:
Mungo's wiring is very similar to how I intend to wire Rufus, the main difference is that Rufus will have a larger electric panel, probably around 50% bigger which will enable a more uniform layout. The following was my modus operandi.

1. Measure up and make a template for the electric panel.

2. Trial fit the panel to Mungo's inner bulkhead using anti vibration mountings.

3. Decide what I want on the electric panel.

4. Space the items on the electric panel, mark and drill the holes and mount the items with A2 stainless fixings, I mostly used M5 and M6.

5. Make a plywood template for the dashboard.

6. Fit the dashboard template.

7. Fit the driver's seat.

8. Fit the steering wheel.

9. Sit in the car and mark the areas of dashboard that cannot be seen; i.e. those areas obscured by the steering wheel.

10. Remove the dashboard.

11. Decide on what items I want on the dashboard.

12. Cut them out in cardboard and lay them on the dashboard in areas that remain visual.

13. Once happy with the layout use the template to make the dashboard.

14. Add two M6 holes, one to take a ‘P’ clip to locate all the cables firmly where they leave the dashboard. The other M6 hole is to take an M6 screw that is a common earth point for all the instruments lighting earth terminals.

15. Fit the gauges and switches to the dashboard.

16. Fit the ‘P’ clip to the dashboard.

17. Draw each circuit up in a notebook etc.

18. Wire the instruments and switches passing each cable through the ‘P’ clip and leaving each cable an extra 500mm longer than it needs to be to reach the electric panel. (At this stage I have not wired up the instrument illumination lights).

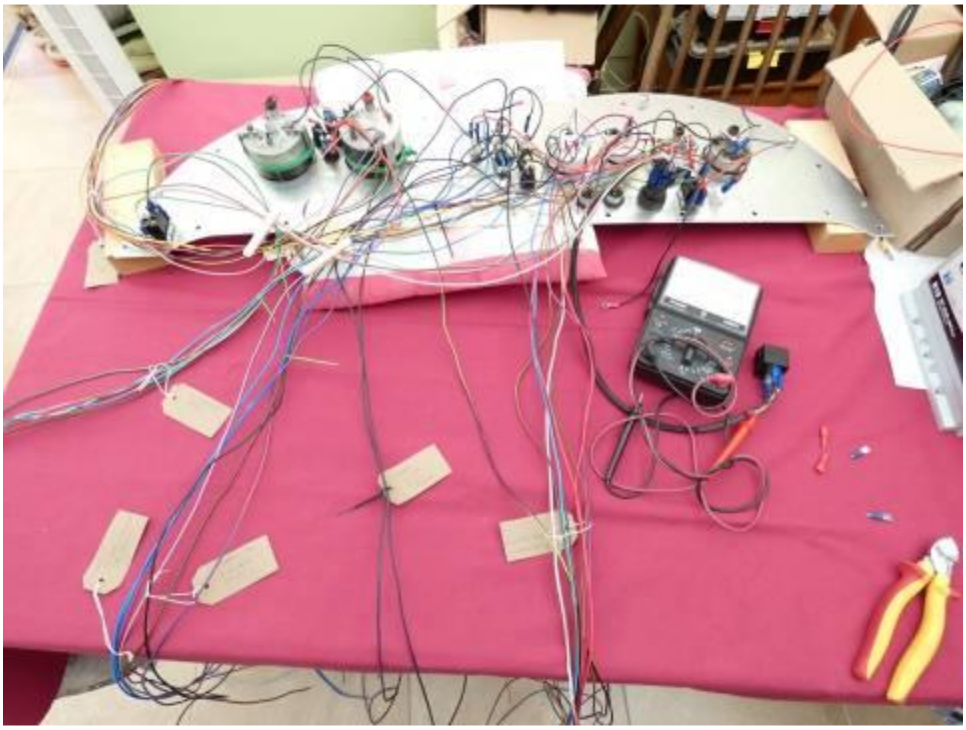
19. Test the dashboard against the electric box to make sure everything works.

The wiring looks a bit of a mess.

I could have just had one thick loom, but such a loom becomes very unwieldy, and it is difficult to store the excess out of the way once the dashboard is in its final position. “Remember that the wires are left oversize so that the dashboard can be unfastened and moved to the rear to enable easy access instead of grovelling under the dashboard. Continue as follows.

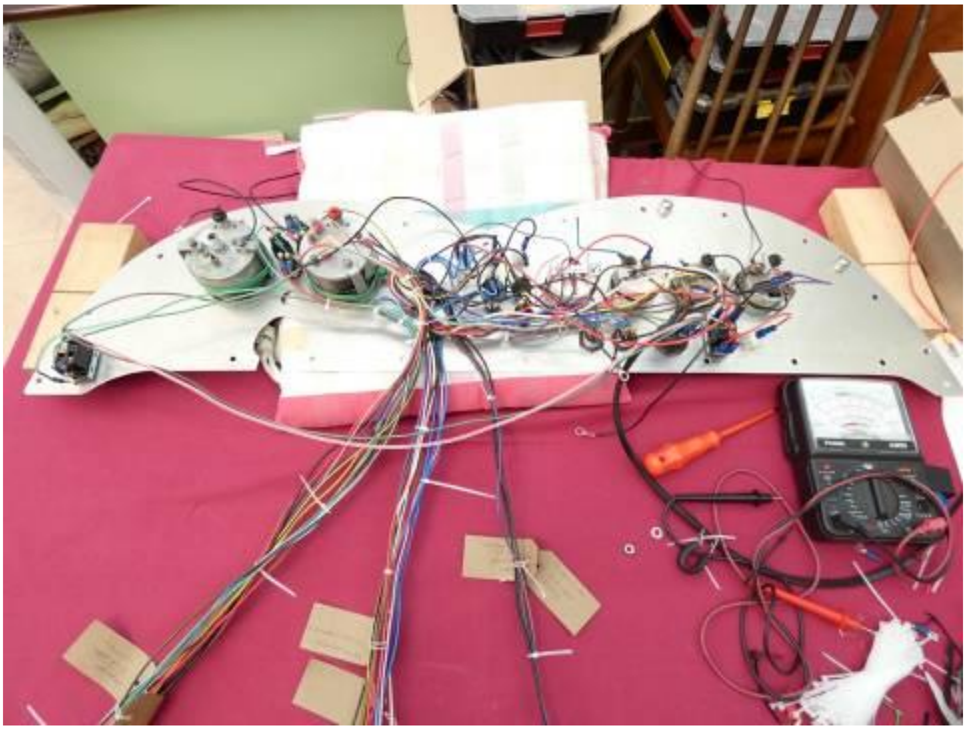
– Sort the wires out into different looms.

– Separate the different looms and label them.



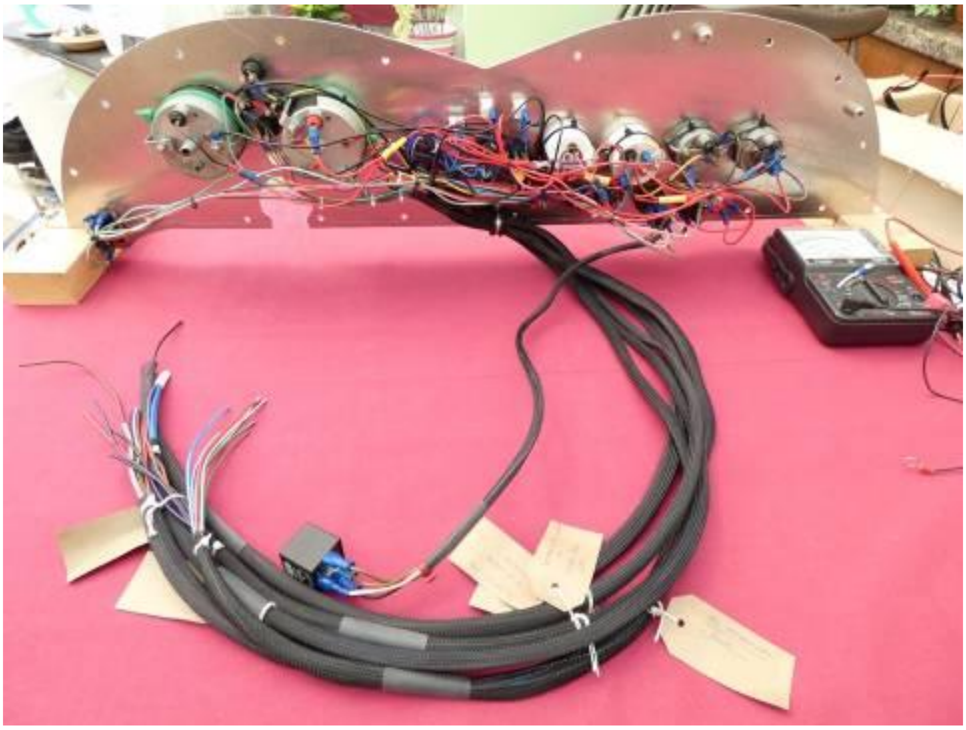
Looking better.

1. Taking one loom at a time carefully adjust the cable path so that the individual looms are neat and not tangled with their siblings.



That's more like it.

2. Apply loom sheaving and fit heat shrink sleeving to the ends, also apply a cable tie for extra security.



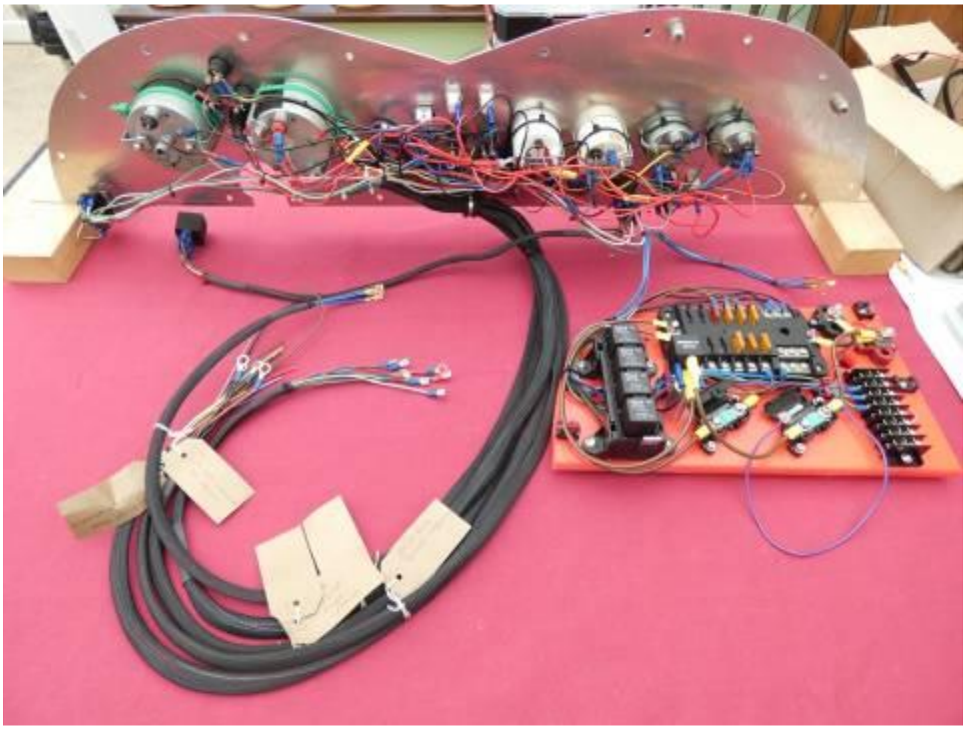
Looks almost finished.

3. Connect up cables to the instrument lights, I took one feed from a dedicated switch (that is powered by the main lighting switch) and used Yellow 3-6mm in line connectors to make joints.

4. Wire in earth leads from the M6 stud to each instrument.

5. Wire in a lead from the voltmeter gauge earth to the M6 earth stud.

6. Put the appropriate terminals on the ends of each loom cable, fitting a loom connector (plug and socket) where the four dashboard cables join the cables from terminals #86 of the four relays.



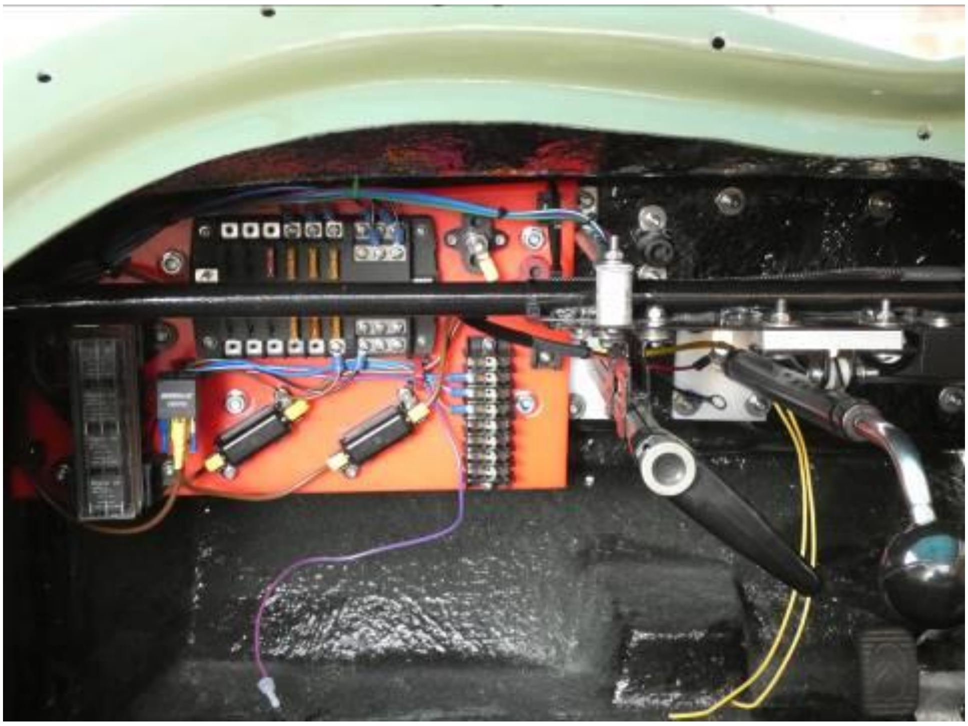
Now it's ready for fitting in the car.

The other side.

Now cut away on the lower edge to make it easier to get in and out of the car.

Before fitting the dashboard I made up two small looms, one took the cables for the DIN battery charging socket and engine cut out switch, the second one connects the brake light switch on the pedal box.

At this stage I fitted the electric panel to the inner bulkhead, then with the dashboard to the rear I made the loom connections to the electric panel etc.



The electrical panel mounted in position.

Next I fitted the dashboard to the car using M6 stainless button heads, the stainless steel grab handle was then fitted using two M8 hexagon head screws. Finally the reinforcing aluminium angle piece** was fitted to the lower edge of the dashboard, again using M6 stainless button heads.

Note.
*** This would not be satisfactory if your car had yet to pass IVA. It would need to be padded following the latest IVA curvature recommendations.*

The final job is to coil up the spare loom and cable tie it out of the way.

With the dashboard in place you cannot see the electrical panel.

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Summary:
Not a difficult job if you approach it methodically.