

Although these are guides, the author does not advise anyone to actually build or even consider building such devices. Read, but do not act upon this information. Everyone should just live a quiet, pastoral life because the dogs of law lie around every corner and I have no wish to be closed down like other useful websites from threats by parasitic lawyers. (When lawyers get rich, society gets poorer.)

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A Beginners Guide to Motorcycle Wiring. plus Trike and Car bits.

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Introduction.

This was originally a motorcycle wiring page. Because of the poor standards of trike wiring, trike wiring was added. As trikes often use car engines, the next step was natural, - to write a monograph on cars. Unemployed, I only have a ten meg site. The car wiring took up too much webspace and was deleted, so I've added a few paragraphs for basic custom car wiring to this monograph.

In many ways, this also applies to boats, as I'm a plant and marine engineer by trade. My marine guide awaits sufficient requests.

Wiring a motorcycle, trike or car is not expensive and only needs a little time and knowledge of the subject to get the basics right. Once the basics are right, the rest becomes fairly straightforward. The wiring of a car has been added where appropriate, as it is usually easier, apart from the engine management and computer systems.

This is not a definitive work on all the various and somewhat dubious electronics or other strange components which contain a wire or two and used on vehicles. This beginners guide is also to act in a support role for the other builders guides.

This monograph includes what is needed for road legal requirements, with extras added for the normal adaptations and flourishes required for customs and unusual machines. This is based on first hand knowledge of building award winning and reliable custom bikes and trikes for over twenty years, plus many radical machines as well.

A storyline wiring guide for Harley owners is also on this website.

The subtle and far more delicate development of HPV cycle wiring is described in the composite HPV cycle monograph by the author.

The advantage of doing the wiring oneself is that it is tailor made and can be easily modified. When things go wrong, the fault finding and repair can be done by the rider, on the side of the road, usually with minimal delay.

The aims of the monograph is to remove the mystery of motorcycle wiring, to enable the reader to rewire without specialist abilities.

Trike wiring is very similar, with differences described where needed.

Car wiring for the more sensible customs is simply separating and adding the engine management systems, then doing the rest of the wiring using traditional methods described herein.

The main aim is to design and make a wiring loom to a standard every bit as good as the best customs. This is done by initially keeping the process on the most basic level needed for the purpose. Only when the basic wiring is reliable, should the reader consider adding flourishes.

If some of the explanations given seem really simple, please bear with this, as there are absolute beginners out there who need the simple explanations to make everything understandable. We were all beginners once.

It is assumed the reader has almost no knowledge of electrics. This is to make it as simple as possible to wire a bike, trike or basic car. Therefore this monograph is not a complete technical manual, as to make such a tome would require many volumes, loads of theory and maths. This would simply confuse more than it would encourage, probably having most bike builders throwing it in the trash or through a window.

This monograph is mainly for a total rewire, starting from scratch, as this is surprisingly much easier to understand and then build. The text was originally mainly for Japanese bikes, as they had effectively set the present standards for wiring vehicles, with sections on others where needed. The Italians are now set to overtake the Japanese - watch this space.

Trikes and custom cars often have lower specifications and needs.

One thing needed to go with this text is the wiring diagram for your particular vehicle. Trikes rarely have such luxuries but motorcycles and cars have the workshop manual. I've drawn some generic wiring diagrams for the unlucky.

Without a wiring diagram, you will need to follow the text to find out what wires go where. Then note down on paper where they go, what they do and their colours. An A3 sketch pad and pencil is priceless. If your motorcycle or vehicle has no wiring at all, then choose the wiring diagram to match the engine rather than the bike.

Use the diagrams accompanying this monograph to get a close match if you can't get a wiring diagram. A selection of basic, generic diagrams are given at the end of the monograph. These are done at a large scale suitable for printing or as a starting point for using in a paint programme for modification as needed. They can be copied and pasted or imported into a paint programme size of 800 x 600 pixels in black and white, although the incredibly simple Harley one is in colour.

This text is not one of chasing particular colours of wires, but to understand the basics of where the wires come from, where they go to, and what they do. - For example, a typical description of 'the alternator wire' means a wire connected to the alternator, not a specific colour of wire to be chased by someone who is not too sure, but a simple electrical connection of a wire. When you know the alternator, you will know the wire and what it does.

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SECTION 1.

Intro and theory for those who have never done wiring before.

Safety and working practice.

Always have decent tools and know how to use them.

Wear eye protection where appropriate.

Do not use mains (120 or 240volt) operated equipment such as soldering irons or electric drills in the rain.

If there are any suspect electrical tools, such as with broken wires, then repair or replace.

The liquid in the battery is an acid which must be treated with care, do not get it on your skin or eyes, this acid can damage paint and rot clothing, and the gasses can be flammable.

The low voltages of 6 volts and 12 volts used on motorcycle's won't harm you, but the High Tension from the spark plug lead will give you a shock which you will feel, but again should not harm you. At least you will know the coil is working. Skimping or doing a quick lash up to get to the big custom event is never recommended, so get the right pieces ordered early, then plan plenty of time for understanding and building the wiring.

Forcing parts of your bike apart will do more damage than making a cup of tea, then thinking about the problem for ten minutes, only to realise an obvious mistake such as the screw or hidden component you had not noticed.

Wiring a bike should be a positive experience, not a hassle.

When beginning a total rewire, make life easier for yourself. Get some plastic bags to hold the parts, preventing them from rusting or getting lost. Keep all parts, no matter how bad, and run a clean, neat workspace.

The worst case scenario is a totally burnt out wreck of a bike, with dubious heritage and a different engine to standard. Don't panic.

The electricity and sparks are generated by the engine and this is where you start. The rest of the wiring on the bike will follow naturally. It is quite common to use completely different components from other machines to make a perfectly reliable machine.

Before removing the wiring, make a note of which side of the battery is connected directly to the frame or chassis. If it's on the positive side (+) then you have a fairly old or peculiar bike or car, and you will have to bear in mind that this book is directed at modern machines which have negative earth systems, (-) but are much the same in most other respects.

What your vehicle needs - the basics.

A means of generating electricity.

A means of storing the energy generated.

A means of making sparks at the correct time.

A means of starting the engine.

A means of warning of possible problems, oil pressure, water temperature and neutral light.

What your vehicle needs - the law.

This will depend upon the country of use, but most are common sense. It is assumed the normal items are required by the rider for road use. Headlight with main and dip beams not less than 25 watts each, the dip beam dipping to the nearside (left in UK, or right in the USA and mainland Europe.), centrally aligned and such that the dip beam will not dazzle oncoming traffic. Cars have two headlights and tail lights etc.

A red tail light, 5 watts.

A red brake light, 21 watts.

A white light to illuminate the (rear) number plate. (Often done by the clear section of the tail light)

A horn of 'strident and consistent note'.

Indicators may not be mandatory, often decided by the age of the machine, but where fitted must be orange, with bulbs of at least 18 watts, and flash between 50 to 70 times per minute - about once a second.

The UK 'Constructions and Use Regulations' lays down requirements on road vehicles, but the only ones you may need to know are the minimum tail light reflector size and

special cases such as motorcycles without head or tail lights during daylight use. Common sense will usually suffice. Check local and federal laws in your own area, or use standard commercial items.

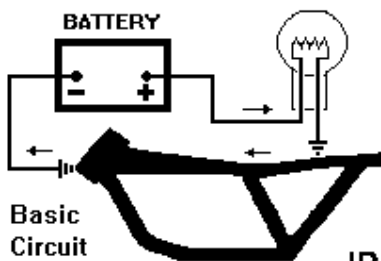
The law is usually fairly open and depends on the age of the bike or registration date. In some countries, Mr Plod will often only require reasonable and sensible requirements, whereas some European super efficient bureaucrats and their mindless minions will require the right number on all the bulbs or indicator lenses and such like to prevent becoming a criminal.

The EC 'empire of paperwork' requirements are still country dependant, but may well soon coagulate with type approval creating constraints on what can be changed or modified on a motorcycle or other vehicles. Any new 'requirements' will hopefully not affect the electrics, apart from moronic bureaucratic ideas such as having the correct number stamped on indicator lenses etc. It is hoped that legislation is for the betterment of all, without restricting the aspirations of the innovative in society. When creating a machine, always try to live in the real world, not one created by lawyers. Only suffer enough bureaucracy to prevent you being considered a criminal.

Luckily wiring is not a great problem for most builders, as aftermarket components are now becoming legally acceptable in a form acceptable worldwide.

Know your countries requirements to live in harmony with your local form of 'normality'. Your vote counts. Never give your vote to someone who wants type approval or other stupid ways of excessively controlling the people, their machines and their aspirations.

There are also regulations concerning radio interference, so the bike will not cause interference with other equipment. The main culprits are the spark plugs which can be shielded with metal caps and a resistor in the plug or in the cap (but not both).



EARTH SYMBOLS



The Basic Words and Theory.

What the parts do and how they do it.

Circuit.

A circuit is simply a 'loop' of wires and any other parts which can carry electricity around it.

Usually from the battery positive terminal, to a 'load' such as a bulb, and then back again to the battery negative terminal.

For example, electricity can run from a battery + positive end, through a wire to a bulb then from the bulb to a lump of steel or aluminium (such as a bike frame - called the 'earth') then through another wire back into the battery at the - negative end. If it all makes a circuit then the electricity will flow around this loop and the bulb will glow. Note the small slotted arrow heads where the wires touch the frame. These are symbols which represent an earth connection, and this usually means the frame or other part of the bike used as an earth. The two other common earth symbols looks like a garden rake and the other is a representation of a metal tag washer, as used by a bolt to hold a wire to the frame.

Earth.

A common method of removing the need for extra wires from various parts of the bike returning back to the battery. The bike frame simply becomes a 'big wire' carrying electricity back to the battery to complete the circuit. On most modern machines this is

connected to the negative side of the battery.

(On older machines it may be to the positive side of the battery CHECK !)

Open Circuit.

An open circuit is when a circuit has a break in it, preventing the electricity flowing around the circuit. This could be a blown fuse, a broken wire or simply a switch which is in the off position.

Short Circuit.

A short circuit is when a part of the wiring becomes damaged allowing the electricity to go more directly to an unwanted place causing problems. Such as when the wire going to the bulb is broken and connects directly to the earth, so the electricity is allowed to flow freely between the positive and negative ends of the battery, which will then cause the wire to get very warm and the battery to drain of power very quickly. Usually when a 'live' wire becomes bare and touches the frame. - Usually protected from causing too much trouble by a fuse.

Fuse.

A fuse is small piece of metal designed to melt if the circuit it is protecting starts to use more electric current (in amps) than it is designed for. Fuses are measured in amps and independent of voltage, so almost any fuse can be used in 6v, 12v, 24, 110, 240 volt and most other voltage systems, AC or DC.

A fuse will spend it's whole useful life waiting to commit suicide to protect your expensive components.

Wire.

A wire is a number of strands of copper metal to carry electricity, covered in plastic to prevent the copper making unwanted contact with other items. The thicker the wire, the more AMPS it can carry. (No excuses offered for mentioning this very basic description.)

Very thick wires used for the starter motor and earth are called cables. Copper wires when corroded often turn black. Some copper wires are 'tinned' - covered in tin or solder for protection or to assist soldering.

Amps.

Amps is a measure of the amount of current flowing through a wire or electrical device, similar to the number of gallons of water flowing in a pipe.

Volts.

Volts is a measure of the ability of electricity to overcome resistance - similar to the pressure of water in a pipe.

12 volts will have a problem pushing its way through your body, 10,000 volts will find it easier. - ouch! High volts and high current equals death.

Watts.

A watt is the measure of the power used - measured by multiplying volts x amps.

If your bike is 12v and has a 60 watt headlight bulb, then it needs 5 amps of current.

Example . . 5 amps x 12 volts = 60 watts and so this basic headlamp circuit will need at least a 5 amp fuse to protect it, usually a 7 amp fuse for the normal safety margin to prevent it blowing too easily.



Spark Plugs.

Spark plugs are simply ceramic insulators mounted in a convenient threaded metal housing, holding a central wire in such a way that a spark can jump across a gap and thus encourage the fuel and air to burn.

The engine gets hot, so spark plugs are available in a variety of heat ranges so the plugs will not get too hot, yet still be hot enough to burn off any dirt on the insulation, especially in two strokes.

The gap must be the correct size, usually about 0.6 / 0.7 mm and is adjusted by bending the outer earth electrode. Spark plugs can be cleaned, gapped and reused many times.

Please note: Some spark plugs have internal resistors and are usually marked with an 'R' in their type number, and the printing on the insulator is often blue. Such plugs should not be used with resistored plug caps.

Coils.

Ignition coils.

Ignition coils are usually large black or grey round chunks with thick wires coming out. They change the 12 volts (or 6v) up to about 10,000 volts to jump the plug gap to create a spark. Coils have two types of external wires, LT for the normal 6v or 12v, and the thicker external high tension (HT) which leads to the spark plug.

Generator coils.

These live in the generator and produce electricity from magnetism. Here is an example of a basic lighting coil which will happily supply lighting for a head and tail light. This item produces AC current, which may then be rectified and regulated to 12 volt DC. For lighting use only, it can be used as unrefined AC current, with no other consideration other than balancing the power of the lamps, so as not to blow them at full engine revs. If the lights blow, fit larger voltage or wattage lamps.

Contact Breakers.

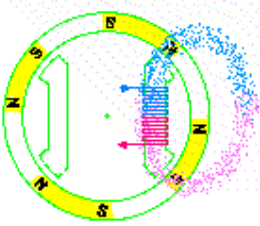
Contact breakers are commonly known as POINTS. A simple mechanical switch opened and closed by a cam mounted at the end of the crankshaft or camshaft. These switch the coils on and off, to make the plugs spark at the right time - when the fuel and air are compressed and ready to burn.

Condenser.

The effect of the COILS cause a small spark across the POINTS causing them to pit. A capacitor (usually known as a condenser) is connected across the points to reduce this pitting. Any bike or car condenser will do in an emergency. They usually look like small canisters with a mounting bracket which connects to earth, and a wire which connects to the contact breaker wire.

Advance / Retard Unit.

The advance and retard unit is a set of weights which senses the engine speed, making low speed running of the engine easier by retarding the ignition timing. (Making it happen a little later at low speeds.) This makes the sparks occur at better times for the different engine speeds. As the engine revs increase, the weights fly out, changing the timing. At higher revs, the ignition timing is at 'fully advanced'. Can be done electronically on modern machines. Advancing the ignition is not often used on two strokes.



Battery.

A battery is a chemical device to store electricity. It contains lead plates and an acid which will strip paint and rot clothing.

A clear battery will allow the plates to be seen for damage and any settled bits at the bottom. When the liquid evaporates, the battery acid must be topped up with distilled water to just above the plates.

A 12volt battery needs 13 to 14 volts to 'push' the current through it to charge the battery. Putting 12 volts across a 12 volt battery will cause nothing to happen.

Where required, some batteries are supplied with special nuts and bolts which are coated to reduce corrosion.

Starter Motor.

A starter motor needs a large amount of current to turn the engine over for starting and therefore needs a much thicker starter cable, and a solenoid to switch the high current used.

Starter Solenoid.

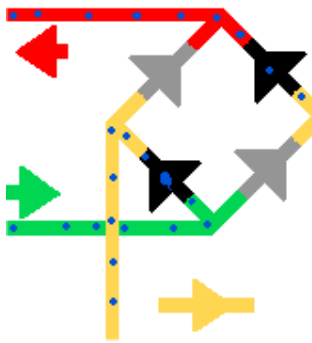
The starter solenoid is a heavy duty switch for the large current (measured in amps) used by the starter motor. Usually controlled by a smaller switch on the handlebars of bikes and trikes, or by the ignition switch on trikes and cars.

Alternator.

An alternator is a device for making AC electricity from a spinning magnetic field. The magnetic field can be made by permanent magnets, or using electricity to generate this magnetic fields, in a 'field coil'.

Cars have self contained alternators.

In the simple animation, typical of a small motorcycle, there are four or more magnets inside the rotor (it rotates), such that as they pass the stator (static) coils, they induce a changing north - south - north - south alternating magnetic field in the iron plates of the coils, thereby generating an alternating current of electricity in the copper coils of wire.



AC and DC.

AC is alternating current. DC is direct current.

AC electricity is made in the alternator at about 30 to 40 volts, with about 60 to 150 amps depending on the type of bike, AC is not suitable for charging batteries, which needs DC electricity. AC electricity is therefore changed into

DC by the rectifier, and adjusted to the correct voltage level by the regulator.

AC flows quickly back and forth along a wire, hence 'alternating', whereas DC flows in one direction in the wire.

AC is often comically referred to as wavy electricity, and DC as straight electricity.

Rectifier.

A rectifier is a bank of one, four or six diodes which allow electricity to flow one way. The rectifier uses diodes which are a form of one-way valve for electricity. By careful design, the alternating current is controlled so all the energy flows one way, giving DC current. DC electrical energy can be stored in a battery and then used by the rest of the bike when needed.

In the simple animation, note that the alternating current in the yellow wires alternates in direction, but by using the diodes, the current comes out in a single flow in the red,

and back along the green. The red usually goes to the battery and the green is usually the earth.

On small bikes, just one diode can keep costs very low which only uses half the AC current, but usually manages to charge up the battery on bikes, where the main AC current is used to power AC lighting.

(A standard 12 volt 36 watt lamp can use 3 amps of AC or DC current to light equasally well.)

The simplest is a single diode for charging a battery on a small bike. for larger machines, then four diodes are used and the animation shows how alternating AC current flow is changed to DC direct current flow at the red and green. The diodes are acting like one way valves and this is how they are also checked.

Regulator.

The regulator keeps the electrical circuit at a constant voltage of 13.8 volts or 6.8 volts depending upon the machine. This stops bulbs from blowing and delicate electronics from damage. The regulator and rectifier are usually in one unit on modern machines.

Dynamo.

A dynamo is an older version of an alternator which internally rectifies the electricity to DC, but it needs a special regulator box with relays to keep the voltage constant and to isolate the dynamo from the battery when the engine stops.

Dynastart is a dynamo which can also act as a starter motor when its mounted on the end of the crankshaft.

Electronic Ignition.

Replaces points and advance units etc, and doesn't wear, so gives accurate timing of the sparks and removes the need for routine adjustment of points. Can fail instantly, needing replacement. Repair of individual components inside the main unit is unlikely. See alternative CDI replacement later.

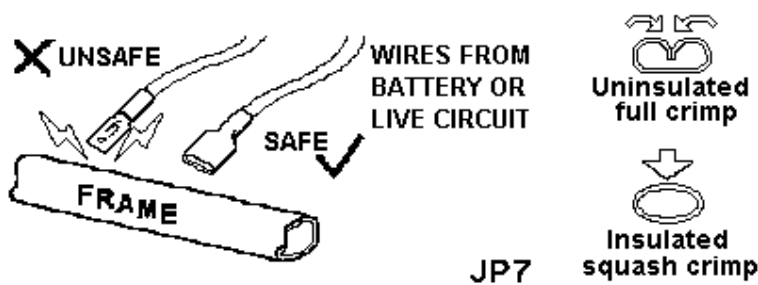
Fuel Injection.

Fuel injection replaces carburettors and choke by spraying fuel into the engine in set amounts at set times, under control of electronics and sensors which constantly read the state of the engine, temperature and throttle etc. Can be separate fuel injectors for each cylinder, or a 'single point' injection, acting like a single carb for a multi cylinder engine.

Engine Management System.

Engine management systems are not used on bikes yet, but will be used in the near future. EMS use one or more computers to check many of the vehicles needs and modify them as changes occur. It controls the ignition, fuel, cooling and often many other parts. Some systems can take care of problems caused by wear in the engine or can even sense and automatically shut down the fuel to a damaged cylinder or failed spark plug to prevent further damage. Whether they are a good idea for the real world is a matter of conjecture, as they offer some technical advantages over more basic systems, but at the expense of increasing complexity and many other disadvantages.

Loom.



A loom is a collection of wires, bound together in a single group or groups. Prone to corrosion, mechanical wear and vandalism.

Sensible routing can reduce most problems.

Connector.

All connectors match as male and female pairs.

Bullet connectors look like bullets and are in sizes of 3.6mm and 3.9mm diameter.

3.9mm are common on Japanese bikes.

Spade connectors are flat. Sizes vary including 2.8mm, 4.8mm, 6.3mm and 9.5mm wide. 6.3mm the most common as used for coils and horn connectors.

Multipin connectors can be made from spade or bullet types and packed into units so that they can only be fitted together one way.

There are two main types of connectors available. The best by far are those using separate sleeves with full crimping tabs (see later). All new bikes use these and there are direct replacements available for nearly all bikes. The other common type are pre-insulated and are instantly recognised by their coloured sleeves, usually red, yellow or blue, depending on size and not recommended as a first choice.

Soldering is used where a wire needs to go to two places at once, such as the lighting wire going to the tail light as well as the headlight dip switch. Strip the plastic insulation back about 5mm, twist the copper inner wires together and solder them until the solder flows freely to make a good join, then clean off the flux and cover using either insulating tape or heatshrink sleeving. Some big Japanese manufacturers do not remove flux whereupon corrosion can occur early and some have been known to fail within three years of leaving the factory.

All connectors on the battery side must be shielded so that if one becomes loose and separates, then the bare end will not short out against the frame or engine, this is done by using the connector half which uses the full length insulating sleeve.

It is for this reason that even the simplest component such as a brake switch will have a male and a female connector. The shielded connector should be the 'live' one.

Why have connectors when it's simpler to just twist the wires together and tape over them? It's simple to do, but annoying when you have to take it apart again and still remember where they go. If you are going to keep the bike, or wiring it for someone who will, then do it right first time, with no further problems.

Heatshrink.

This is plastic tubing which shrinks to a smaller diameter when heated. The best type has sealant inside, so that the join will remain waterproof as well as protected electrically and physically. Silicone or other sealant can be applied prior to using ordinary heatshrink to the same effect.

Switch Types.

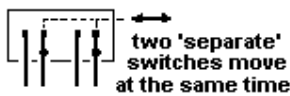
The simplest is used for horn, brake light and starter, which simply connects two wires together only when the button is pressed, and is often known as a 'push to make' switch.

A switch which connects two contacts together and stays in place, as used for the lights switch, is a simple on/off type known as 'single pole, single throw' switch (SPST). This

SINGLE POLE DOUBLE THROW



DOUBLE POLE SINGLE THROW



JP7

switch can 'throw' one way or the other, and can be used for the dip switch to send the electricity to either the high or low beam.

The switch used for the indicators needs to connect the wire from the flasher unit to the left side contact for the left indicators or to the right contact for the right indicators. This is a single pole double throw. (SPDT) It can switch one wire (pole) either of two ways. The centre position usually does nothing.

Imagine two SPDT switches, connect them side by side and working off one lever, this is a 'double pole, double throw' switch, (DPDT).

Ignition Switch.

The ignition switch takes electricity from the battery via a fuse and when switched on, allows the electricity to be used by the rest of the motorcycle.

On a small bike, the ignition switch may also short the ignition wire from the points to the spark plug coil and short it to earth when in the off position, so that the engine won't run.

See also ignition switch repair later.

Oil Pressure Switch.

This is usually mounted on the engine and is either a low pressure unit for machines with roller crankshafts, or high pressure for most other bikes. The usual method is to have a wire from the ignition circuit to an insulated warning light, with a wire to the oil pressure switch which shorts the lamp to earth to complete the circuit. Simply test with the engine running, as the oil pressure should be able to switch off the warning light within a few seconds.

Oil Level Switch.

A simple switch mounted on a float, to warn of low oil level, usually for two stroke oil tanks.

Car switches.

For legal reasons, it is not acceptable to place switches on the dash which can impale the driver in a crash. Therefore rocker switches are now common, rather than the older lever switches with their handles sticking out of the dashboard. This does not limit good design too much and can offer some interesting designs.

The indicator switch is probably the hardest to get half decent, but there are a few dash mounted types available. If a pair of push buttons are used, then a switch in the steering can be used for the off switch, with a little electronics and a distance timer for safety switch off.

Car Ignition Switch.

The ignition switch takes electricity from the battery via a fuse and when switched on, allows the electricity to be used by the rest of the car. As the lights use a lot of power, these take their power via a relay direct from the battery, with a small connection on the ignition switch operating the relay for the lights. Likewise for the starters position on the ignition switch which also operates a heavy duty relay (solenoid) for the starter motor. The steering shaft lock is also included, with tamper proof retaining bolts. The latest cars have no ignition key, but a pass card or sensor which can be circumvented for more easily made custom vehicles.

Relays.

Relays are heavy duty power switches which can be operated remotely by ordinary switches. The classic case is when needing a hi/lo switch to operate a powerful headlight. The normal handlebar dip switch will soon burn out trying to switch the large amount of current, so a relay is used. The normal dip switch is used to make the relay switch between the high and low beam circuits. The full power goes to the relay, then to the headlight. The handlebar dip switch is only used to control the relay.

Relays can allow the handlebar dip switch a much simpler on/off switch. Where possible, the relay can be mounted inside the headlight close to the headlight, minimising the amount of wiring required.

Relays come in many types, single pole single throw, double pole, double throw, with or without fuses and other arrangements. Use to best effect.

Headlights.

Headlight shells contain the lens unit in the correct alignment, usually by W clips in a chrome rim, or a pivot and an adjustable screw. The W clip method will have an alignment lug on the lens which must align in the shell so the lens is the right way up. UP is often marked on the lens. Always use at least three W clips, preferably four, so the lens will remain in place if one clip fails. The lamp unit will vary according to manufacturer. Fitting of a higher spec bulb may require the replacement of the whole lens unit for different or larger quartz halogen lamps. Do not touch the glass (quartz) of quartz halogen lamps as they are prone to damage. They can be cleaned with paper tissue and alcohol.

Many modern headlights are all plastic and little repair is possible, although some can be modified.

Tail Lights.

Basic light in a red cover. Sometimes with a clear panel to illuminate the number or licence plate. The single bulb usually contains two filaments, (pieces of tungsten wire which glow brightly.) These filaments are different wattage's in a tail light. The high wattage for the brake light, the smaller for the tail light. Usually 21 and 5 watt.

Tail lights can have two bulbs for reliability, as it is difficult to see when a bulb fails, which can leave the rider in a dangerous position, especially on motorways at night. This can be a pair of dual wattage bulbs, as the tail light wattage is low, and the higher wattage of the brake lights is only momentary.

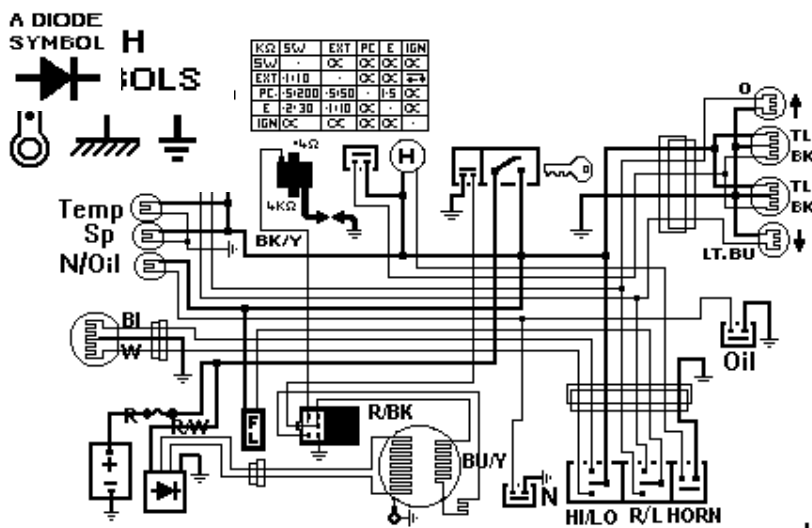
Fog Lights.

Fog lights should be worked via a relay connected to the dip light. When the dip light is switched on, the wire to the dip lamp should also supply power to another switch. This second switch can then operate a relay which will switch on the fog lights. As fog lights will not work effectively with main beam, due to the effects of fog, the fog lights need only be used when in fog and the dip is used. Best mounted low, to maximise visibility in poor conditions. Always use a fog light warning light, which is usually orange.

Spot Lights.

Same as fog lights, but working on the main beam via a switch and relay. They work off the main beam switch so they do not dazzle in town where dip is used. Often mounted at headlight height for maximum visibility of the road. Always have a spotlight warning light, which is usually blue.

Wiper motors.



These sometimes contain a dual speed system in the unit, but can be circumvented for external timed wiping. Always fit the whole system as a complete unit as it came out of the donor car, so it works reliably. A rotary switch or potentiometer is idea for dash board control, with a button beside for washing. If the rotary switch is on a rubber mount, a

push to wash button can be used integrally.

A Guide To The Wiring Diagram.

General points. The wiring diagram for the average vehicle is an awful confusion of many wires, all of which seem to be going everywhere.

This is a basic wiring diagram for one of the authors 125's. It does not follow standard practice, uses a single fuse and a modified C90 CDI unit to replace the more expensive original item. Most wiring looms can be built to personal preference.

A wiring diagram is like a London underground map, (a classic piece of design) as it is a schematic. That is to say it approximates to the layout of the actual item. For wiring diagrams, the description 'approximate' takes many liberties. These liberties usually make for an easier to read drawing.

To understand a wiring diagram, the main signposts must be recognised. The lights, battery and switches are simple. The rest of the gaps can be filled in with a little time studying the drawing.

The small squares where some wires cross, represents an electrical connection, often a soldered joint, although it can mean any other method which manages to do the same. All other wires cross independent of one another. Where the tail light assembly and the handlebar switch is removable from the loom, the two rectangles represent the multi-pin connector.

One concept can be represented many ways. The earth connection symbols can vary from a representation of a tag to bolt to the frame, to a line entering a solid surface or a spike into the ground.

A single symbol can represent many different items. The diode symbol may represent a single diode, or a more complex electronic device such as a rectifier/regulator unit.

There is a trend in the car market towards totally unreadable wiring diagrams, often based on a numbering system. This may be acceptable for manufacturers who simply describe and replace parts, but is not remotely usable in the real world. Always draw a wiring diagram schematically, so it can be followed logically. If a very complex wiring loom is needed, then simply break the wiring down into discrete chunks, drawing each system on a separate sheet. Do not follow car practice and have many cross points to save a few wires, but make stand-alone circuits, independent and robust in their operation and reliability.

Hidden in this mess is usually only four different circuits. These are the charging circuit, to generate and store the electricity. The ignition circuit, to start and run the engine. The lighting circuit. The auxiliary circuit.



How to read a wiring diagram. Only the modern car wiring diagrams seem to be designed to be incomprehensible. For most vehicles, a wiring diagram can be read easily, if you know the language. It's usually in an anorak form of English.

Although you may have a specific problem to overcome, take some time to understand the layout. Start with the battery and ignition switch and fuse box. From these, the various other components can be discerned, then the wiring leading to and from them.

As all wiring diagrams are different, the following guide is common to most modern motorcycles. If yours is very different then tread carefully, but the differences are usually small, as there is only certain things that can be done with wiring.

Typical alternator symbols are from left to right, star wound, delta wound, two separate coils (as on most small bikes) and a symbol of a sine wave, as generated by an alternator.

Wiring.

To make life easier, the plastic insulation which covers the wire has a main colour and often a smaller tracer colour moulded into it. The main colour usually shows which main circuit it belongs to, and the tracer showing which part of that circuit it is.

Most colours are represented by single letters. Red (R).

Unfortunately, more than one colour begins with B. For British, North American and Japanese, black, brown and blue become double letters, (e.g. BK, BR, BU), so read the table on the wiring diagram of your manual to tell which is which, or make your own rules if you have no wiring diagram. Where some colours are lighter, such as light blue, the LtBU is a common abbreviation also DkBN for Dark brown. For Italian and German machines, these letters will be different, based on their local languages.

For example if the whole of the lighting circuit is white, then a white wire with a red tracer showing that this particular wire goes to the tail light (W/R) and a white with blue tracer to the main beam (W/BU). The builder of a custom machine may prefer to use colours which are easily understood. In this case, the tail light is red, hence a red tracer. This is not standardised for most vehicles, but can make life easier if designing your own wiring.

Colours are standardised for each manufacturer, an earth lead on a Kawasaki will be the same colour on another Kawasaki, but not necessarily the same colour on a Yamaha. Distinct circuits are often given standard colours eg: all earth wires are the same colour.

After a basic understanding of the components, now to put them together. A guide to where electricity starts on the machine, to where it ends up.

The Alternator And Charging Circuit.

An alternator makes AC electricity (alternating current) by a spinning magnetic field which creates an electrical force in windings of copper wires.

The constantly changing North - South magnetic field induces current flow in the copper windings and out comes alternating current.

The magnetic field can be made using permanent magnets or by using electricity in a 'field coil'.

The AC electricity produced is changed to DC electricity (direct current) by a device

called a rectifier which is then regulated to about 14 volts for a 12 V bike. (7 volts for a 6V bike).

This DC electricity can then be used to charge up the battery and supply the lights etc.

If you put 12 volts across a 12v battery nothing will happen, if you more volts across the battery, then there will be enough difference in voltage to cause electricity to flow and charge the battery. Too much voltage will slowly cause the battery to heat up and dry out, eventually causing damage and bulbs to blow. Too little voltage will not allow the battery to be charged.

Some bikes will have alternators similar to cars, which are usually open to the air with cooling slots. These are often self contained units delivering 'ready to use' DC voltage and so the alternator sections below will be superfluous.

Check your wiring diagram or use one from the selection at the end of the monograph. Find the alternator which is usually shown as circle with symbols representing coils of wire, these are often as a triangle or a wide 'Y'. An 'S' shape on it's side can also denote alternating current.

On most bikes, usually look for two or three white or yellow wires.

Larger bikes with traditional alternators will have three white or yellow wires coming from the corners of a triangle or 'Y' star of coils. On a few rare machines there may also be a field coil with one side connected to earth, the other wire going to the regulator.

When the engine is opened up, there may be nothing remotely similar to the wiring diagram, as it is a 'schematic'. The actual components are usually resin covered lumps of copper wound over steel plates riveted together.

Check for any physical damage. If damaged, either carefully deconstruct and rewind with identical varnished copper wire or have it rewound commercially or replace. See later. The wires coming out from this device are the main areas of concern. The two or three yellow or white wires can be easily replaced.

The small steel arms wound with copper are the alternator windings, and can be from just one winding the size of a thumb for a moped, to a dozen smaller items on some big bikes. All sizes and shapes available.

The rotating flywheel will contain permanent magnets which will attract steel tools.

Clean off any excess magnetic debris or rust. If there are no permanent magnets, then there will be a big bobbin of wire in the middle, this is the field coil.

The two or three yellow or white wires will go to the rectifier. This usually also contains the regulator. The rectifier is a simple bank of diodes which allow the alternating current to be rectified so it all comes out 'flowing in one direction' as DC direct current. The rectifier has the white or yellow wires going in, and a red wire coming out, plus an earth wire, or is earthed via a mounting bolt or its metal casing.

If the rectifier and regulator are separate, then the rectifier output wire will go to the regulator. The regulator constantly regulates the voltage at approx 14 volts.

The output from the rectifier/regulator will go to the battery, supplying the 14volts DC ready to charge the battery and supply the rest of the bike.

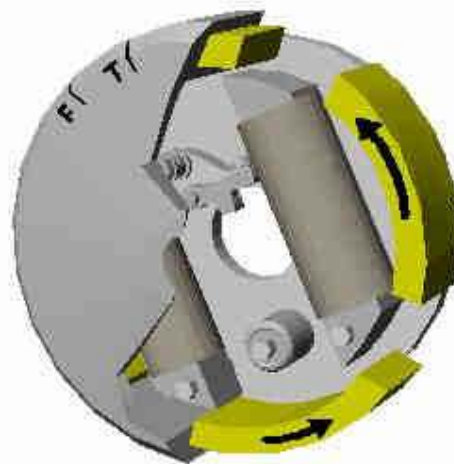
The regulator may have an earth wire, denoted by its colour. Where appropriate, always make sure the finned metal body of the regulator is well earthed via its mounting bolts.

The regulator may also have a sense wire. A sense wire is usually slightly smaller, which is used to sense the voltage in the main loom. This allows the regulator to keep the voltage correct. This sense wire should be connected to the output side of the

ignition switch, usually where it joins the three fuses. If fitted, do not connect this wire on the main fuse side of the ignition switch.

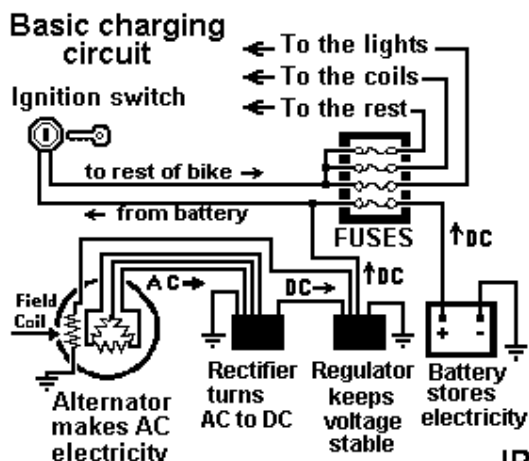
Holding the regulator or the remains of a regulator in your hand, the two or three white or yellow wires are easily recognised. Then the thick red wire, again easy to see. The earth wire, if fitted will be the same size as the red wire. Any other wires will be the sense wire, or if the original engine of this rectifier has a field coil the any left over wire is almost certainly the field coil wire. If no field coil then it's probably a sense wire.

If the alternator has a field coil, the regulator will have an extra wire and this wire must be connected to the field coil. Check by comparing the colours of the wire from the field coil to match any on the regulator unit. An alternator with a field coil must use a regulator for the field coil type. If in doubt, check with original wiring diagram for the specific bike. This wire will usually be routed beside the three white or yellow wires, entering the alternator, and going to the bobbin of wire in the centre of the alternator. As the engine revs more, the alternator pumps out more electricity, so the field coil is lessened, keeping the output steady. If the lights are switched on, the field coil is given more current and up goes the alternator output. A very efficient design.



(C) J.Partridge. 1999

On a small bike, there may be two separate long straight coils of windings inside the alternator. The one with the thicker copper wires with fewer turns is the winding which generates the battery and lighting electricity. There may be two wires. Probably one white or yellow wire, which often goes directly to the light switch for direct lighting. Another wire will go to the diode to charge the battery. See later. The other coil supplies the sparks and is part of a completely different circuit.



You now know where the electricity comes from. It is generated as AC at around 30volts. This is then changed to 14 volts DC and stored in the battery, ready to be used, so make a sketch for your machine. Draw the alternator, the AC wires to the rectifier and regulator, then to the battery. Do not forget the earth connections on the rectifier / regulator and the earth wire from the battery to the frame to complete their circuits.

The battery has an earth wire usually on the negative side and this goes to the frame. Older bikes may have a positive earth, check first.

If the machine has a starter motor then the earth wire will be a thick cable and may connect directly to the engine crankcase. The positive side of the battery will use a thick cable to a heavy switch called the starter solenoid and from this to the starter motor.



A wire on the positive side of the battery also goes to the main fuse. The main fuse is usually connected close to the battery, so that all subsequent wiring such as those leading to the ignition switch and all other wires are thereby fully protected. Most main fuses on larger bikes and most car-based trikes are about 30 amps.

A wire from the main fuse goes to the ignition switch. From the other side of the ignition switch, a wire goes to the three ignition, lighting and auxiliary circuit fuses. The ignition switch may also switch parking lights and other components, but is otherwise a simple on off switch, usually with an integral steering lock to deter theft. As the ignition fuse, lights fuse and auxiliary fuse are often in the same fuse box as the main fuse, the wires will lead from the main fuse to the ignition switch and back again to the fuse box.

Because the wires from the regulator to the battery, from the battery to the main fuse, to the ignition switch and the wire back to the three fuses must carry all the electricity for the bike, it is therefore a little larger than the rest of the wiring. These wires are slightly larger and capable of about 15 to 30 amps depending on the machine.

For those wishing minimal wiring, just the main fuse will do, although if something causes the main fuse to blow, then all the electrical items will stop working. See later.

Small bikes.

On small bikes, the engine mounted alternator will probably have two separate coils. One with lots of turns of finer wire, supplying the sparks, the other with fewer turns of thicker wire, being the 'alternator'. This alternator coil may have wires coming off it at different points. If so, then you have a circuit which uses the full winding to power the lights directly, plus a part of the winding to charge the battery. This set-up may have the charging adjusted by a separate switch, which connects only a small part of the alternator coil to the wiring when not using the lights, and the whole of the coil when the lights are on. This is called a balanced system and is a cheap way of removing the cost of a regulator unit, simply replacing it with a cheap diode to convert the AC to DC to charge the battery. Most filament lights as used on motorcycles can use AC without any problems.

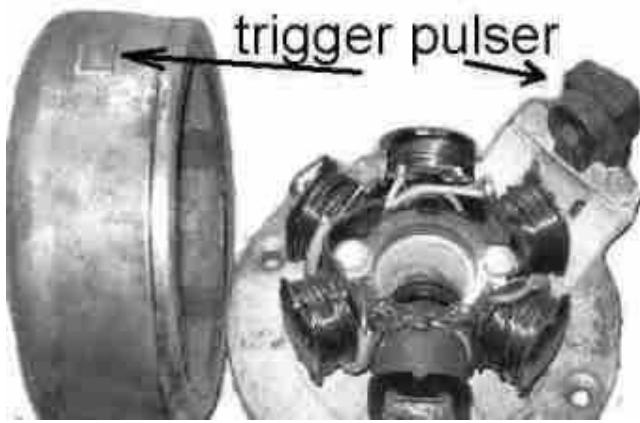
Inside the basic flywheel rotor are usually two main coils. One coil is fairly large and supplies about fifteen to thirty volts AC to the rectifier for the battery and lights. The other coil is a smaller, more finely wound coil to supply a hundred or so volts to the CDI unit.

Outside, or sometimes inside is a small, finger tip sized pulser coil, which triggers the CDI at the correct time for the spark.

This picture shows a C90 rotor with the pulser interrupter on the outer edge, which caused the timing pulse at the right place, and the pulser is the black lump between the rotor and stator. Lying flat is the stator plate with the pale lighting and dark CDI generator coils.

There are four magnets inside the rotor, such that as they pass the stator coils, they induce a changing north - south, then south - north alternating magnetic field in the iron plates of the coils, thereby generating electricity in the copper coils of wire.

As can be seen, the four poles at the ends of the coils means that the magnets in the



rotors are four, so the N-S-N-S field flows strongly through the iron cores. This is acceptable for a low power machine, but sometimes a little more electrical power is needed in such a small space, so six poles can be use, with six rotating magnets. Now we are six. The black and white picture shows another popular arrangement, where the lighting

coils are the five coarsely wound coils, while the generator is the obviously different one nearest the viewer. Again the pulser is outside. You will also notice that as a six pole stator, the rotor should have six magnets. You can just make out the size and layout of the six magnets inside the rotor.

Although these systems are not perfectly balanced with a constant voltage, the output is such that it will usually do the job. If under powered with a dull glow, simply use a lower wattage headlight bulb. If overpowered and bulbs constantly blow, then fit a larger wattage headlight bulb until the system is 'balanced'.

Another problem is if the battery cannot charge fast enough, then fit lower wattage indicator bulbs (if the law permits) and don't stop with the brake light or indicators on all the time, thus draining the battery. Indicators and brake lights are usually the main culprits which quickly drain the battery on these minimalist systems. Connecting just the rear brake light switch, while disconnecting the front brake light switch often suffices.

Summary.

At this stage the wiring diagram should show the AC from the alternator, through the rectifier / regulator unit to charge the battery.

Stored electrical energy is supplied from the battery to a main fuse, to the ignition switch and back to the fuse box, to connect to three other fuses.

From these three fuses can be connected the appropriate circuits.

Cars have stand-alone alternators with self contained control devices which deliver 'ready to use' DC electricity.

Why have fuses?

Without fuses, any short or other damage to the wiring can cause heat, melting wires or even sparks which cause fire, especially if near the carburettors or the fuel tank.

To prevent anything dangerous happening, a fuse will protect it by committing suicide to protect your wiring and to let you know something's wrong before anything desperate happens, without further damage.

Why have a main fuse if you have three others?

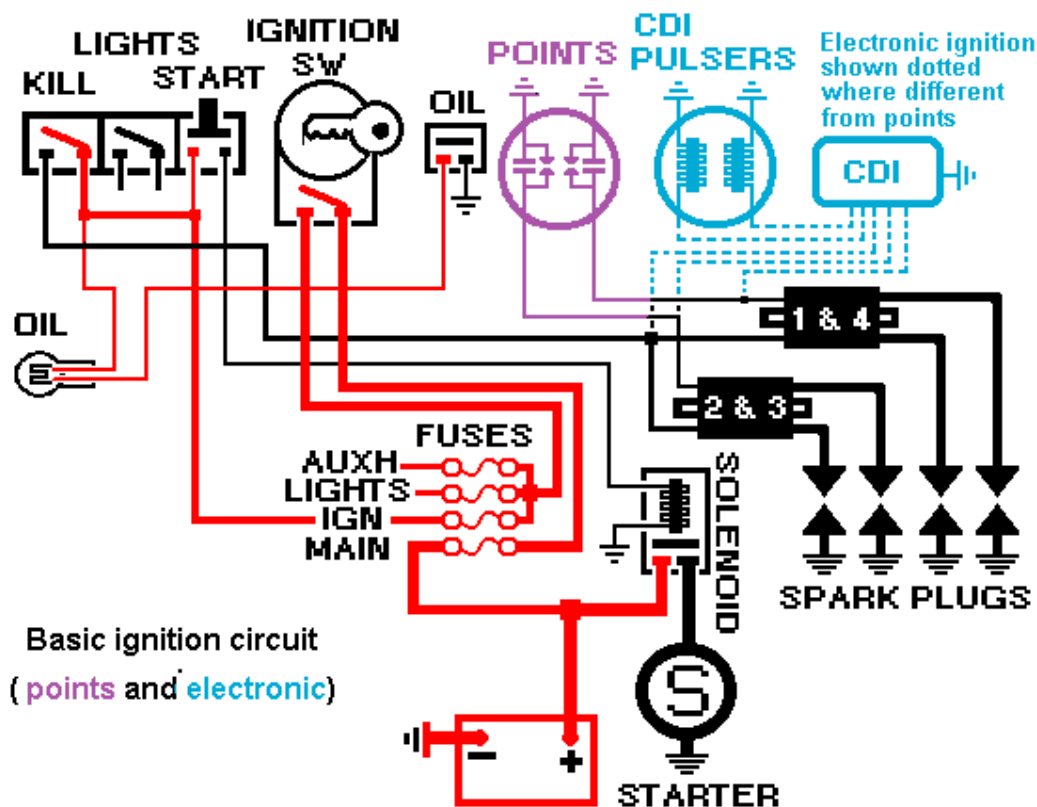
The ignition switch must be protected as it takes all the electricity through it and will be unprotected without the main fuse.

Why not have just one main fuse and forget the rest?

Suppose you're driving along, and a wire on the lights shorts out. - With only a main fuse, all the electrical circuits will stop, including the engine. If you are in a dangerous situation, the last thing you want to happen is to loose all engine power.

If you are riding at night and the engine fuse blows, you don't want the lights to fail at the same time.

By using a main fuse plus three others, there is far less chance of the main fuse blowing first, and all will not fail at once.



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THE IGNITION CIRCUIT.

Please note that small bikes are different, see later.

For Car Ignition Circuit. See below.

From the fuse chosen for the ignition circuit, a circuit can be built to supply the sparks. This may also include the other engine components such as oil pressure switch and electric starter.

Look at your ignition circuit in the manual or use the nearest diagram from the selection later in this monograph.

Find the coils, they are usually big black or grey lumps with thick wires to the spark plugs. On circuit diagrams, spark plugs are often shown as two thick black arrow heads pointing to each other.

On most bikes, each coil should have one or two thick HT leads to the spark plugs, and one or two ordinary wires. One of these small wires will supply the 12volts from the ignition fuse, (via a simple kill switch if used). The other small wire will go to the points or to the electronic ignition unit.

On some small bikes, there may be only one small wire which is connected to the contact breaker and also splits to connect to the ignition coil and the ignition switch. On small bikes, the ignition switch will short out this circuit to earth when the ignition switch is off, to prevent use.

On bikes with contact breakers there is a wire from each contact breaker to each coil. The wire connected to the contact breaker must be connected to the insulated moving contact spring. This wire must only connect to earth when the points are closed, so check the small plastic insulating washers and the spring mounting are correctly positioned. The condensers (capacitors) will connect between the earth via their mounting screw and to the points wire via the spring mounting nut which holds the small plastic insulating washers and points spring and wire in position. When all is assembled correctly, the wire from the coil will only short to earth when the points are closed.

On electronic ignition bikes there are simply pulser coils (sometimes known as pick-ups) instead of contact breakers. The wires from the pulser going to trigger the electronic ignition unit which shorts the coils to earth. These pulser coils are simple coils of wire around an iron core. As a magnet rotates past, a small current pulse is generated to trigger the ignition box at the correct time. See also two stroke CDI later. Alternatively the core of the pulser coils may be magnetic and a ferrous item passes to interrupt the magnetic field.

There will be either one or two wires from each pulser coil. If just one wire, the other end of the pulser coil connects to earth internally. The pulser wires will connect to the same coloured wire from the electronic ignition box.

Likewise on the electronic ignition box, there will be matched coloured wires connecting to the coils. The other wires from the electronic ignition box will be a 12volt supply and an earth which are usually easy to identify. On an engine with two pulsers, it does not matter which pulser wire goes to which wire, as both pulsers are built the same, and the output for the coils will also be the same, but with different times relative to the crankshaft. Therefore only the correct wires for the pulsers must be decided and likewise the wires for the coils. The only minor problem is to make the coils work correctly for cylinders 1&4 and 2&3 by simply swapping the pulser wires, or the ignition box wires to the coils or simply swap the spark plug caps.

If the pulser coils have dual wires, then they may need their individual pairs of wires to be swapped to get their pulses the correct way around.

Cars often use a distributor and therefore only need one pulser, so do not suffer this problem. the problem is getting the right wires from the distributor to the correct spark plugs.

If there are other wires, then they may connect to the tacho, or exhaust valve controller of two strokes, but these will need the manufacturers correct wiring diagram to check.

The 12 volts from the fuse will usually go to the kill switch, then to the ignition coils and also to any electronic ignition box if fitted.

The points will short out the 12 volts in the coil, causing a spark. This is done by creating and collapsing the magnetic field and very high voltage winding in the coil, which must go somewhere, invariably across the spark plug gap causing the spark.

Many earlier contact breaker and pulser systems use mechanical flyweights on an advance retard mechanism to mechanically advance the sparks as the engine revs increase. Later electronic systems use an electronic advance.

The kill switch on larger bikes is a simple on/off switch which if used, must connect 12v to the coils and to the electronic ignition unit only when in the 'run' position. In general use, the kill switch prevents all from being damaged by simply switching off the power to the coils and any electronic ignition box.

During testing, always protect the coils and electronics. Use the kill switch to prevent overheating of the components if the ignition switch is to be kept on, perhaps when testing other circuits. It is best to test each circuit separately using only the fuses as needed, with other fuses being removed for safety.

If fitted, the ignition fuse also supplies power to the fuel pump. A standard solenoid type fuel pump may be supplied with power direct from the fuse or via the kill switch, as it only pumps when the pressure is low. On some racing machines with a motor style fuel pump inside the fuel tank, then this type can be controlled via the kill switch and possibly a tilt switch for safety should the machine crash.

If a fuel injection system is fitted, it should be on its own circuit, supplied via the kill switch.

If the fuel and ignition systems need more current than the kill switch can handle, then all, or at least the fuel pump should be controlled via a relay.

The common type of solenoid fuel pumps use contact breakers inside which can sometimes fuse together and cause damage, therefore it is most prudent to fit yet another fuse, just for the fuel pump and carry a spare set of fuel pump points if touring.

Electric start.

As the electric start is part of the engine, the start button can be supplied with 12volts from the kill switch or from the auxiliary fuse. As the kill and start switches are close together, this is very simple using a small internal wire. As the starter is part of the engine, the kill switch will prevent the electric starter from working unless the engine is ready to run.

On some unusual engines it is often necessary to crank the engine over a few times before running. If wishing to be able to crank the engine without sparks, then the wire from the ignition fuse can go to both the start button and the kill switch. This should be used in conjunction with a system which prevents the starter motor from being used while the engine is running.

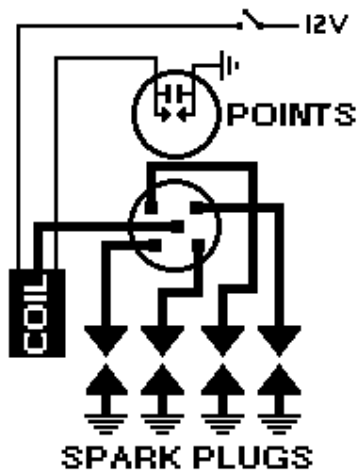
A thick wire known as a cable connects the battery to the starter motor via a solenoid switch which is a heavy duty relay. The starter solenoid is activated by the starter switch on the handlebars.

Starter switches differ. Some take the wire from the solenoid to the handlebar starter switch and short it out through the handlebars to earth, but this sort is not recommended. If the wire should short out between the solenoid and the handlebars, then the starter may work when you least expect it, often requiring new crankcases and a trip to hospital.

The safer design has 12v going to the starter button switch then to the solenoid. If the wire should short to earth, then only the fuse will blow, but the starter motor will not work while riding. To find out which type you have, open the starter button switch to see if one side shorts to earth, or whether you have two wires insulated from earth, which means you have the safer type.

The solenoid gives a loud click when it works. Test by connecting the small wires across the battery.

Some solenoids now include the main fuse, a flat strip of steel held by two screws. Therefore this side of the solenoid must connect to the positive, (not the starter motor) side of the battery. From this main fuse will be a wire leading to the ignition switch. If the solenoid fails, the machine may be started by shorting a spanner across the two



large cable studs on the solenoid, shorting out the connections enough to power the starter motor.

As ignition systems become increasingly complex, more components will be added to the ignition circuit, such as a level sensor which will cut the ignition if the bike falls over. If in doubt about the many spurious or dubious components, find out what each does and leave it out of the circuit if not required.

Usually such items are simple switches connected in the circuits to prevent accidents. To prevent the starter working with the clutch out, a simple switch is connected in the starter circuit, preventing use unless the clutch lever is pulled in. Other systems are simply variations on a similar theme. These are not complex, just annoying when there is more to go wrong.

Summary.

The ignition circuit starts from the battery, then through the main fuse to the ignition switch, back to the ignition fuse. From the ignition fuse a wire goes to the kill switch, and finally to the coils and electronic ignition. The kill switch can also supply 12volts for the starter switch to operate the starter relay.

That's all there is to it, just an ignition switch to make sure you can switch the whole bike off and a kill switch for just the ignition circuit to kill the engine.

The minimum contact breaker ignition circuit is a wire from the ignition switch to supply volts to the coils. Then wires from the coils connect to the contact breakers and condensers.

The minimum electronic ignition circuit is a wire from the ignition switch which supplies the 12volts to the coils and electronic ignition. Wires from the pulsers trigger the electronics box which is connected to the coils.

On small bikes, a single wire goes from the ignition winding (many turns of copper) in the engine, to the points, also to the spark plug coil and to the ignition switch. The ignition switch shorts this wire to earth when in the off position, preventing the engine from running.

A kill switch has many advantages.

To check for a spark, charge up the battery, then lay the spark plugs on the cylinder head and turn the engine over. On electronic ignitions, it may be necessary to kick start or use the electric starter, as there may be a minimum cranking speed for some electronic ignition systems. On contact breaker systems, simply flick the points open and shut. Check for sparks. If no sparks, check the 12 volts supply to each component and also the earth connections. On contact breakers, check for insulated points and spring. On electronic systems look for overheating black boxes and poor connections. Sniff for any burning. See testing later. If all is well, remove the ignition system fuse and prepare to build the lighting circuit.

The Car Ignition Circuit.

From the fuse chosen for the ignition circuit, a circuit can be built to supply the sparks. This may also include the other engine components such as oil pressure switch.

The car set up with distributor is simple and an example is shown. It is refreshing to see such a simple design which has worked so well for millions of people for billions of miles.

Find the coil, usually a big canister with a thick wire to the distributor cap, then to the spark plugs. On circuit diagrams, spark plugs are often shown as two thick black arrow heads pointing to each other.

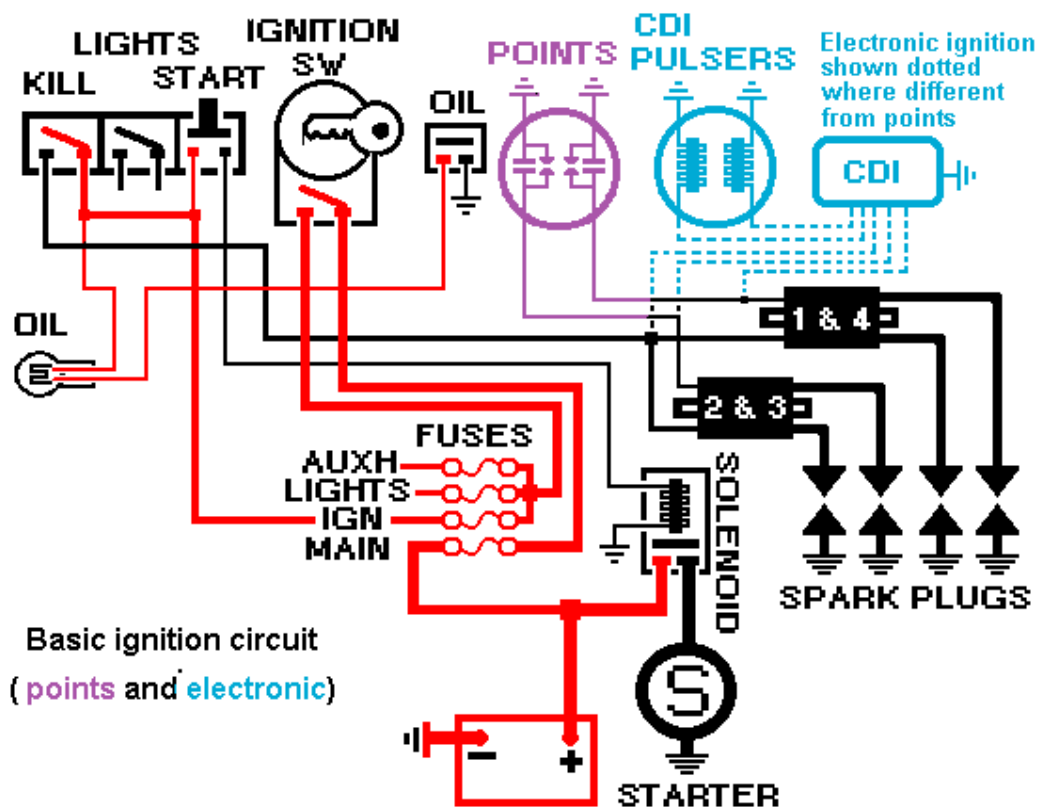
On most basic car systems the coil should have a thick HT lead to the distributor cap and then to the spark plugs, and one or two ordinary wires. One of these small wires will supply the 12volts from the ignition fuse, (via a simple kill switch if used). The other small wire will go to the points or to the electronic ignition unit.

On engines with contact breakers there is a wire from each contact breaker to each coil. Usually one of each, but V6s and larger may have more fun bits.

For points, the wire connected to the contact breaker must be connected to the insulated moving contact spring. This wire must only connect to earth when the points are closed, so check the small plastic insulating washers and the spring mounting are correctly positioned. The condensers (capacitors) will connect between the earth via their mounting screw and to the points wire via the spring mounting nut which holds the small plastic insulating washers and points spring and wire in position. When all is assembled correctly, the wire from the coil will only short to earth when the points are closed.

The other pictures shows motorcycle set-ups. The area of interest is that it can be used in a modern car without the need for a distributor, and two pick ups on the crankshaft position. With this, the coils can be mounted in the cylinder head trough between the cams and make a compact arrangement. This is the way many systems are going with electronics, so you should consider such methods as well as the simpler old set-ups, to keep an open eye on the future. As coils are now very small, some not much bigger than your thumb by using much higher primary voltages from the electronics box, they can now be placed in the spark plug cap, and each coil triggered from the electronics individually rather than via a distributor.





On electronic ignition engines there are simply pulser coils (sometimes known as pick-ups) instead of contact breakers. The wires from the pulser going to trigger the electronic ignition unit which shorts the coils to earth. These pulser coils are simple

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coils of wire around an iron core. As a magnet rotates past, a small current pulse is generated to trigger the ignition box at the correct time. Alternatively the core of the pulser coils may be magnetic and a ferrous item passes to interrupt the magnetic field. There will be either one or two wires from each pulser coil. If just one wire, the other end of the pulser coil connects to earth internally. The pulser wires will connect to the same coloured wire from the electronic ignition box.

Likewise on the electronic ignition box, there will be matched coloured wires connecting to the coils. The other wires from the electronic ignition box will be a 12volt supply and an earth which are usually easy to identify. On an engine with two pulsers, it does not matter which pulser wire goes to which wire, as both pulsers are built the same, and the output for the coils will also be the same, but with different times relative to the crankshaft. Therefore only the correct wires for the pulsers must be decided and likewise the wires for the coils. The only minor problem is to make the coils work correctly for cylinders by simply swapping the pulser wires, or the ignition box wires to the coils or simply swap the park plug caps.

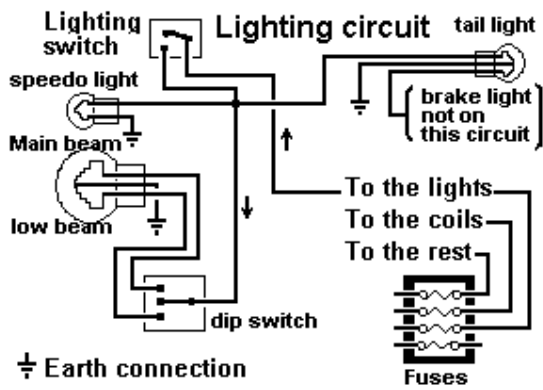
If the pulser coils have dual wires, then they may need their individual pairs of wires to be swapped to get their pulses the correct way around.

If there are other wires, then they may connect to the tacho, or exhaust valve controller of two strokes (snow mobile engines), but these will need the manufacturers correct wiring diagram to check.

The 12 volts from the fuse will usually go to the kill switch, then to the ignition coils and also to any electronic ignition box if fitted.

The points will short out the 12 volts in the coil, causing a spark. This is done by creating and collapsing the magnetic field and very high voltage winding in the coil, which must go somewhere, invariably across the spark plug gap causing the spark.

Many earlier contact breaker and pulser systems use mechanical flyweights on an advance retard mechanism to mechanically advance the sparks as the engine revs



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increase.

Early electronic systems use an electronic advance. This reads the amount of advance to be used according to variables including throttle position, engine revs and amount of vacuum in the inlet manifold. For this reason they are often called a digital 3D map and can be changed for racing purposes, as they are burnt into a chip. A not too

dissimilar arrangement is used when employing a digital fuel injection system.

The kill switch is a simple on/off switch which if used, must connect 12v to the coils and to the electronic ignition unit only when in the 'run' position. In general use, the kill switch prevents all from being damaged by simply switching off the power to the coils, any electronic ignition box and the fuel pump.

During testing, always protect the coils and electronics. Use the kill switch to prevent overheating of the components if the ignition switch is to be kept on, perhaps when testing other circuits. It is best to test each circuit separately using only the fuses as needed, with other fuses being removed for safety.

If fitted, the ignition fuse also supplies power to the fuel pump. A standard solenoid type fuel pump may be supplied with power direct from the fuse or via the kill switch, as it only pumps when the pressure is low. On some fuel injected racing machines with a motor style fuel pump inside the fuel tank, then this type can be controlled via the kill switch and possibly a tilt switch for safety should the machine crash.

If a fuel injection system is fitted, it should be on its own circuit, supplied via the kill switch.

If the fuel and ignition systems need more current than the kill switch can handle, then all, or at least the fuel pump should be controlled via a relay.

The common type of solenoid fuel pumps use contact breakers inside which can sometimes fuse together and cause damage, therefore it is most prudent to fit yet another fuse, just for the fuel pump and carry a spare set of fuel pump points.

The Lighting Circuit.

The lighting circuit fuse will supply 12v to the lights on/off switch. From this switch the wire will split three ways. To the hi/lo headlight switch, to the tail light and to the speedo lights.

The hi/lo switch then connects the high and low connections on the headlight bulb. The wire to the high beam can include a wire to a high beam warning light which will also be on when the high beam is on.

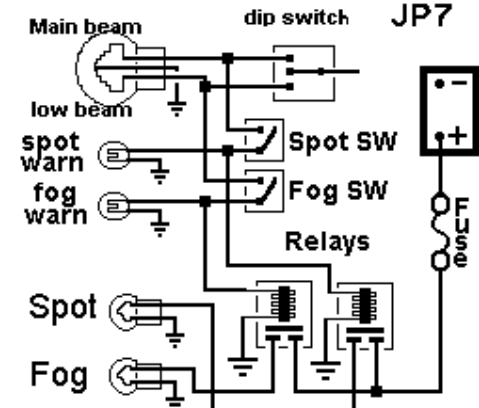
The absolute minimum set-up is a wire from the ignition switch to a dip beam and a tail light.

Some ignition switches have the lights switch built into them. This is common on small bikes, where only a main fuse is used. In such circuits, simply use the lights output from the ignition switch to send power to the hi/lo switch and also the tail light and speedo lights.

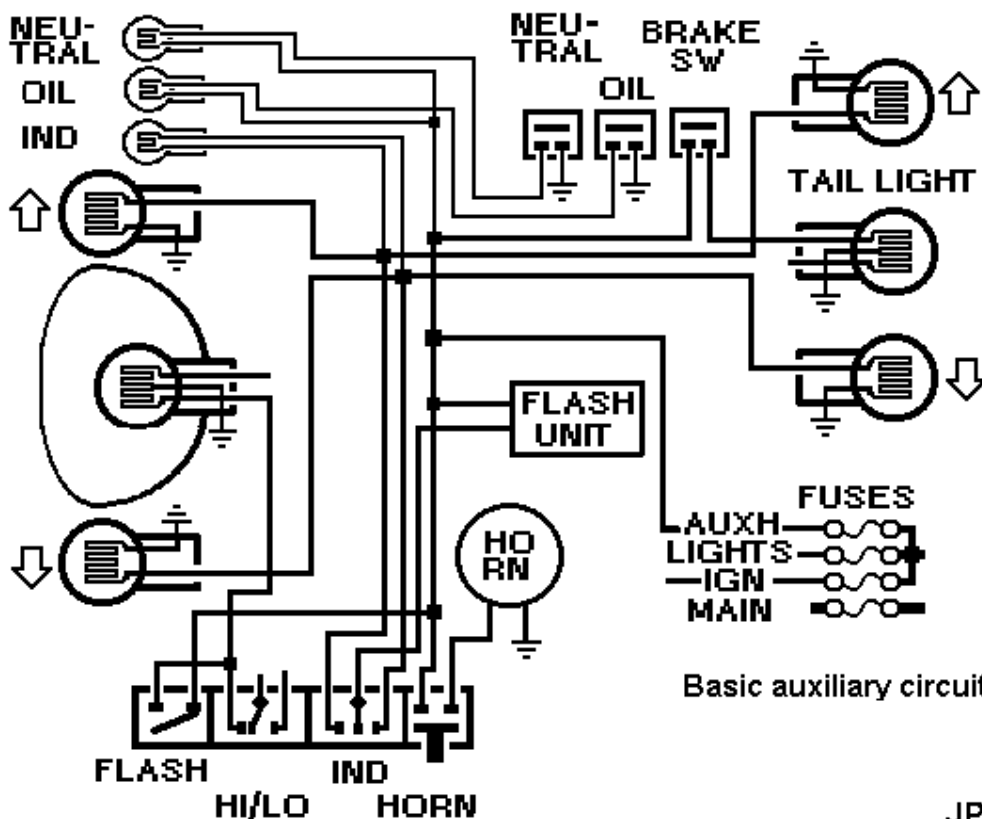
The high beam warning light is simply a small light connected to the main beam wire.

Speedo and tacho lights are simply small lights connected to the light switch.

The headlight flasher takes 12v from the auxiliary circuit. Not from the lights circuit, but usually from the horn button supply which is very close inside the handlebar switch



unit. The headlight flasher can then be used without the lights being switched on, to the flash switch, and from here to the high beam. The headlight flasher switch is usually close to the Hi/Lo switch and may only be a very short wire inside the switch housing to connect to the high beam wire, also inside the handlebar switch housing. See auxiliary circuit.



Basic auxiliary circuit

It is not a good idea to add too many items such as extra lights to the standard lighting circuit, as the ignition switch can only take a limited amount of current. Spot and fog lights should be separately fused on their own circuit from the battery. This way, the main lights are more likely to remain working when needed. Spot and fog lights can be triggered via relays by a connection to the main/dip switch without overloading the main lighting circuit.

The Auxiliary Circuit.

From the auxiliary fuse a number of wires split to supply the Horn, Brake lights, indicators, and other bits and pieces.

Oil warning light.

The most important is the oil pressure or oil level warning light, as this can save the engine from damage. The oil warning light can be part of the ignition circuit if preferred, so no excuses for showing it twice, as it can save an engine from damage, and can be on either circuit. This consists of a wire from the auxiliary fuse to the fully insulated warning light centre contact, then from the light to the oil pressure switch, which simply switches (shorts) the wiring to earth, causing the light to illuminate. The best light holder for this is a basic all-plastic item which has no metal parts other than the two small internal lamp connectors. These are very common and used in most dash boards of cars and bikes.

On two strokes, similar applies, but the oil warning light is operated by a switch in the oil tank.

Horn.

Two ways of wiring a horn. Check the internal wiring of the horn switch. With a horn switch which does not short to earth, a wire from the fuse supplies the horn switch. This then switches power to the horn and then to earth.

Where the horn switch shorts the power from the horn to the handlebars, one of the connectors on the horn gets 12v from the auxiliary fuse (look for a + sign on some horns). The other horn connector takes a wire to the horn switch which completes (shorts) the horn circuit to earth via the handlebars. Simple and effective. See also simpler alternatives for dirt bikes later.

Brake lights.

The auxiliary fuse supplies 12v to one connection of each brake switch, the other connection of the brake switch goes to the brake light in the tail unit.

Indicators.

The auxiliary fuse supplies 12v to the flasher unit which supplied intermittent pulses at about 60 times a minute.

This intermittent supply of 12v goes to the middle contact in the handlebar indicator switch. From this switch the intermittent 12v is sent to the left or right indicator lights.

For an indicator warning light, use a fully insulated lamp simply connected with one wire to the left indicator wire and the other wire to the right indicator wire. What happens is this: when one side lights up, the intermittent 12v flashes the indicators, and also supplies the warning lamp, the very small current used for the warning lamp is small enough to be earthed through the filaments of the other bulbs. No worries.

Read the info on the flasher unit to see what bulbs it is designed for. Usually 2 X 21W + 5W, which means two 21watt lamps plus a small 5watt indicator lamp.

Fuel gauge and sender.

In the fuel tank, a float moves a simple arm which rubs against a resistor. The resistor has volts at one end and the other end is to earth at 0 volts. Little current flows in the resistor, just enough to give a voltage across the wire, which gives zero volts at the earth end and max volts at the other. The current to the fuel sender resistor must be safely limited. Under no circumstances must full voltage be allowed to flow through this internal resistor. Remember the early jumbo jet crash when the fuel tank blew the plane apart.

As the arm moves across the resistor according to fuel level, this sends a differing voltage to the fuel gauge. The fuel gauge simply deflects the needle according to the amount of voltage from the fuel level sender. The fuel gauge usually has 12volt connection, an earth and the sender connection. These should be marked according to the particular wiring of the original bike.

Fuel senders can be modified for various fuel tanks by modifying or bending the float arm.

Water temperature gauge and sender.

Both must be used as a pair using the original wiring circuit of the machine from which they came. Water temp gauges are common on many machines. They are usually from 12 volt machines so can be used on other machines, as water temperature is common to all bikes and trikes.

Water temp has a similar set-up to the fuel up except that the temperature sensor on the engine varies its resistance internally according to engine temperature. The gauges are otherwise very similar.

A temperature operated switch may also be fitted into the hot bits of the cooling system to switch on the radiator cooling fan should it exceed a set temperature.

Parking light.

This may seem a trivial item but prone to a major booby trap.

The parking light takes a wire from the main fuse, usually by connection to the wire from the main fuse. This is usually a small jump wire soldered on the base of the ignition switch. This 12 volts direct from the battery is then sent via a unique position on the ignition switch to the tail and a small light in the headlight, which is dangerous. Warning. If, in the parking position, the 12 volts is allowed from the battery to the parking light, and thus to the tail light, then the tail light is thereby connected to the lighting system! Therefore the lighting system is connected to the main fuse and the rest of the bike via the main fuse. The bike can be run.

The solution is simple. A diode, which acts as a one-way valve for electricity is fitted into the wire from the light switch to the parking lights. This prevents the power from the parking light circuit from reaching the rest of the bike. Such a diode costs a few pennies, and capable of carrying $12\text{v}/5\text{w} = 3\text{amps}$ at 12 volts, so a 5amp or higher rated diode will live happily in the wiring loom. Make sure it is connected the correct way around.

There are other items on machines, such as auto indicator switch offs, and other fancy stuff, but these are often more of a waste of time if building your own wiring loom. A simple, reliable wiring loom which does the job is better than an overly complex loom. If fancy bits are required, simply place them on a separate ancillary wiring loom. Digital speedo and other ancillary items are simply a variation on the above themes, but with a digital interface. See later.

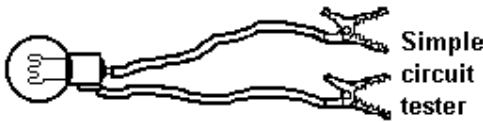
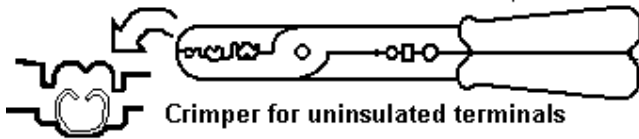
If the original set-up is needed, it is often better to use the manufacturers genuine replacement loom, or to copy the original.

If using or modifying or building alternative handlebar switches but the room for switches is too small, then use small switches to switch a relay. This will allow many of the ultra small switches to be used which can often be carved or moulded into handlebar clamps. Where ordinary electrical switches are used, always use the waterproof version, or employ silicone sealant to waterproof the pivot and any other areas where water will seep in. Alloy coloured silicone sealant makes for easy starter or horn push miniature switches to be moulded directly on the handlebars.

If fitting an internal light to a fitted top box or pannier, then consider quick setting epoxy to glue a micro switch to the case, with the tab bent to release the switch when the cover is removed. This technique can also work for many aftermarket alarms to protect side panels and seats etc.

Checking the wiring loom is simply fitting the appropriate fuses then checking each system by connecting each item in turn, to see if it works are required. Always check the earth connections are well made, including the earths onto the frame so they will not corrode with time. See testing later.

Central locking. Cars think that central locking is a boon. Great until it goes wrong. If the battery dies, then you will need to power up the car from external means. A hidden external 12volt charging socket which supplies directly to one door lock will help you get in ! If you cant get in, you are not going to open the bonnet (hood). A diode may be



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needed.

Otherwise, simply charge the battery from the socket, but if a major fault has occurred, then this may simply not work. A external 12 volt charging

socket will allow the car to be powered up to retain radio and computer data while replacing the battery.

Minimum Tools And Equipment Needed.

Most common tools are used. A home made 12 volt bulb on two wires about one metre long with crocodile clips on the ends, for checking circuits. As simple speedo light will suffice, with the wires lengthened.

Paper, pencil and eraser.

Home made thin spike or flattened wire about 1mm x 1mm x 100mm long, to bend back the tags holding the connectors in multipin housings. A straightened paperclip with flattened end does nicely.

Multi meter to read 60 volts AC to check the alternator output, and 20 volts DC to check the regulator and battery charging. The meter should be able to check resistances up to 50k ohms for coils, rectifiers etc. 10A current measurement is also useful to see how much current each item or circuit is actually drawing, so the fuse rating can be sensible.

Wire strippers and cutters, or a small knife.

Special crimpers for the connectors. (It is well worth the money for a decent tool for the un-insulated connectors, as the crimp will be as good as the very best. See drawing below for the type of crimp it gives.)

Soldering iron, any sort will do. A superior choice is the butane gas type which removes the need for mains connection, and allows the work to be done in situ, often in the street.

For protecting the wiring and connectors, especially for dirt bikes, clear lacquer or clear nail varnish, also silicone maintenance spray and grease. Flexible hair spray will generally protect most wiring and connectors, especially during long term storage.

Penetrating oil for easing tight nuts and bolts in alternators, and switchgear.

If rebuilding switches, then add tweezers and thin, snipe nosed pliers.

Strobe.

A 'strobe' is needed for checking the advance curve and the sparks while the engine is running. This is a powerful lamp which flashes when the spark occurs, causing the internals of a running engine to look as if it is standing still. If too expensive, a timing light is much cheaper but with equivalent lower performance, needing to be used in darker light levels. If preferring to try a simple alternative, a cheap or surplus neon mains warning bulb will do, and can be wired using HT leads directly in the spark plug HT circuit using parts from a broken plug cap. This can be brought close to the timing marks for easier vision. A neon bulb is the small warning light on 240volt kettles and mains sockets which glows red - not exactly brilliant, but very cheap and can do the job for pennies if insulated well.

SECTION 2.

Rewiring for those who know the basics.

The basic car and motorcycle wiring looms are essentially similar, as they both simply do the same thing.

The following is mainly for a typical basic Japanese 4 cylinder rewire with:

Four circuits. Charging, Ignition, Lights and Auxiliary. With a fuse for each circuit.

An ignition switch.

Fuse box for four fuses plus spare fuses.

Rectifier / regulator unit.

An electric starter with solenoid.

Two coils to 4 spark plugs from 2 sets of contact breakers or electronic ignition.

A headlight with dip and high beam, tail light with brake light working off a rear brake switch.

Horn.

Indicators.

Standard handlebar switches, containing lights on/off, high/low beam, starter, kill, and horn switches.

The circuit is conventional with negative earth.

Before starting a rewire.

I often rewire a bike from a burnt out wreck, with just a few corroded stubs of wire coming from the crankcase. If you do your homework properly, then this should be an opportunity to do a new, really neat and tidy job.

First of all and wherever possible, get the engine running before removing the old wiring. This reduces the numbers of possible problems to be solved later, such as the electronic ignition, or coils, or ignition switch work etc. This also helps to understand the wiring before removing the old bits. Take this opportunity to see if the battery charges at 14 volts or if there are charging problems.

This may well require taking a few liberties by making a lash-up piece of wiring to check the components.

If the vehicle is burnt out or a wreck, then it may be best to get the engine running first.

This is particularly useful before spending money on the rest of the project. The engine can be temporarily wired to run from a fully charged battery, to get just the sparks and starter motor working. This will not need the alternator or charging circuits. Just rig up power to the coils and points or electronic ignition and pulsers, powered direct from a well charged battery. Do not forget the earth connections.

The electric starter motor can be operated direct using the remains of the starter cable or a pair of emergency car jump-starter cables.

Once the engine runs, the rest may be worthy of a rebuild. Start by thoroughly cleaning all components. Where the wires to the alternator are burnt flush, remove the alternator and use new wires soldered to the original connections to the alternator windings. Leave plenty of length on the wires for fitting later. Likewise the pulser units and any other wires in need of repair. Always make sure they are routed safely and neatly.

Switches can be chosen as required, then checked with a multimeter and possibly repaired or even modified.

Other items such as radiator fan and temp switch can be checked while off the machine. Use boiling water to check the temp senders.

If a burnt-out wreck, then also replace the thermostat which has probably burst. The electrics may be damaged, but the internal components fare surprisingly well, even in the worst circumstances. The fuel flames usually consume the carburettor or injectors,

but alternators and starter motors always seem to remain usable, but should always be stripped, cleaned and inspected for long term reliability.

Items to bear in mind when designing the wiring.

Checking the parts. Whether you are using non-standard new, or used parts from the bike, the internals must be checked to see how they are wired up internally. Where problems occur, then testing will be needed. This can be done as each stage of the wiring is reached. Three ways are possible; Testing with a multimeter, taking it apart, or reading the original manual. Taking components apart and modifying is covered in section 3.

Once the switches are understood, drawing the wiring diagrams can begin. If parts such as switches, coils, regulator etc, were working all properly before the rewire, then little can go wrong unless they become wet, corroded or broken. See repair later.

If deciding on your own colour scheme, then the following points should be considered. Choose appropriate colours for the different main circuits, with different tracer colours to indicate the parts of the circuit.

For example, if making the lighting circuit white, then you could have a white wire to the light switch, two white wires with red tracer from this switch to the tail light and to the high/low switch. From the high/low switch a white wire with a blue tracer to the high beam and maybe a white wire with yellow tracer for the low beam. This simply mimics the colours used by the lights.

Whatever colours you decide, make them simple to understand and mark them clearly on your wiring diagram.

Wires from the alternator are usually yellow or white.

Charging systems and the main supply to the ignition switch and fuses usually use red as their main colour.

Earth is usually green for Honda, Black for Kawasaki etc.

Keep it standardised where possible, as this will tie up nicely with the unmodified components such as electronic ignition, indicators etc.

Choosing The Wire Size And Connectors.

The size of the wire depends upon the CURRENT in amps it needs to carry. (not the volts). The appropriate way of working out the size of wires needed is given in Section 3. If in any doubt, use wire capable of carrying around 8 Amps for most wiring except the following.

The wires capable of carrying about 20 Amps (possibly 30 amps on big bikes) from the battery to the ignition switch, and back to the other fuses in the fuse box.

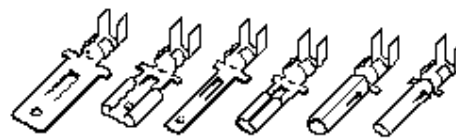
For the starter motor, use the original or a special starter cable, plus a similarly thick cable for the battery to engine earth connection.

The power to the starter motor usually returns via the crankcases, which is then connected to the battery via a suitably sized cable. An earth will also be needed between the battery and the frame. Do not assume an engine earth is a good frame earth, as some engines are rubber mounted, and paint or corrosion between frame and engine can also cause problems.

Make a list of wires required by using the wiring diagram. Decide upon the length needed and by measuring the bike, then add some extra for possible errors in cutting or bad fitting to make life easier. It is common to order to the nearest metre anyway. A typical list is given in Section 3 to act as a guide.



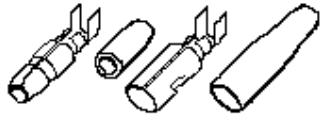
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Multipin connector types



Uninsulated flat blade and sleeves



Uninsulated bullets and sleeves JP7

All the connectors disconnected, must have shielded multipin housings to accidentally them on your wiring how many are

that are 'live' when be prevented from circuit. They **MUST** sleeves or shielded protect them if disconnected. So mark diagram and count needed.

Keep standard connectors on the electronic ignition, alternator, rectifier and regulator, so when they need replacing, new parts will fit without problems. If the original connectors are damaged or lost, you can often get some from a breaker, then simply buy new metal connectors to fit inside them.

Multipin connectors have metal inserts which are a little longer than the standard connector, which contain an extra retaining tang to retain the contact in the plastic housing. This is easily bent back enough for careful removal and re-use. Use a straightened paper clip with a flattened end.

Some bike breakers will be only too happy to send you out to the broken bike section with a few tools to scavenge a wiring loom for a few quid. Use this opportunity to salvage any other components that are due to be dumped, such as battery cables, fuse box, broken speedo units to recycle the fuel gauge etc. If the exact bike is not available, the nearest equivalent will often supply most of the required connectors.

Unusual or special connectors can come from old or similar looms. A few uncommon connectors are not available such as some oil pressure switch connectors, so will have to be recycled or made to fit other connections.

The internal metal connectors of multipin block connectors can be replaced where needed, using new pins which come in most shapes and sizes. To decide which ones you need, use a small thin, flattened piece of wire to push back the locking tab on the metal part inside the housing, then pull it out. It is best to try this on an old connector first as it can be fiddly.

If you decide to cut the wiring to a minimum then you can still use standard switches etc, but circuits such as indicators may not be needed.

Designing a Wiring Diagram.

If never having done any wiring before, then this may be simpler if each circuit is designed on separate pieces of paper, by working through each circuit using the text described earlier.

Once it is decided that they are correct, they can then be put all together on one complete wiring diagram. This may take a couple of attempts to get a clean looking diagram.

With the diagrams as a guide, draw the battery, fuse box, alternator, regulator/rectifier, lights, switches and any other parts used in a similar position to those shown on the wiring diagram, or modify from the drawings given at the end of this monograph. A simple paint programme will allow cut and past to suit, moving the parts around to personal preference, then simple line drawings to join them up correctly. This is then followed by an important item left off the diagrams, namely the wire colours.

Start with the yellow or white wires from the alternator to the rectifier/regulator unit. See also field coils and sense wire above which may or may not be needed. Then continue with the 12 volt wire from the regulator to the battery. Usually red. This also goes to the main wire from the battery to the main fuse. The earth wire is usually black or green, to the frame earth.

From the other side of the main fuse, draw a wire to the ignition switch. From the ignition switch when in the 'on' position, back to join to the three other fuses. The three fuses then supply current to their different circuits as mentioned earlier. Join the parts up using the descriptions given earlier. Ignition circuit for the coils and spark plugs. Then draw in the lights circuit and then the auxiliary circuit. It will be instantly noticed that spacing is paramount to a neat wiring diagram. After a few attempts, the wires will soon take up a natural 'schematic' arrangement, eventually leading to relative clarity.

Although drawing a wiring loom may seem a chore to many bike builders, it has one major advantage. It enables the wiring to be sorted before the build. By drawing the loom, the way it is assembled and works will be double checked, with any problems sorted well before hassles can raise their heads. It also leaves a permanent record for later when problems may occur.

Another major advantage is that you work out just exactly what it is you are doing, before getting lost in a mess of loose wires and connectors.

Some bikes have the fuse box in the fairing, with the main fuse on the starter solenoid. This will simply require a little repositioning of the items on the wiring diagram.

The earth wires will be the same size as the wires supplying 12v to the component, except the battery earth and starter which must be a little larger. The starter motor cables can be drawn in a little thicker to the solenoid and the starter motor, plus the thick earth from the crankcase to the battery earth.

Mark in the colours as they are drawn, so each circuit can be easily recognised.

Parking lights are usually connected through the ignition switch, occasionally needing trial and error with a multimeter to find out which wire from the ignition switch will work parking lights. Warning: a diode will be needed, as mentioned earlier. Stay clear of parking lights unless absolutely necessary or consult the workshop manual. The diode is to prevent the power going via the parking light to the lights switch to the fuses, then allowing the rest of the bike to work. See parking lights above. If in doubt, make the parking lights on a completely separate circuit to all other wiring, and connect direct to the battery via a simple switch. Do not connect to other lights.

You should now be able to draw a wiring diagram, or follow a wiring diagram for your bike.

Follow each wire in turn starting from the battery check if they end up in the correct place and colour, and that you know what they do. A selection of basic wiring drawings are available at the end of this text.

Practice fitting each type of connector you will be using, including soldered joints and switches. Test by trying to pull wire off to ensure it's fitted securely.

Some Tips On Custom Rewiring.

Decide where your wires are going so you can get the brackets and any access holes in the frame done before you do any final welding or paintwork on the vehicle. There are many ways to hide the wiring, but this will need a good deal of thought to get right and still allow you to be able to take the loom and associated parts off the bike, trike or car. Experience shows that it is very important to understand what wires you need, so you can use the minimum number of wires. This is then followed in some circumstances by needing small connectors, so they can go through the holes in the headlight and into the frame tubes. Make sure there are no rough edges in these holes, as a short circuit here is no fun! Drill the smallest access holes necessary, then insert a strong bar and bend the hole to allow the wires to enter at a more suitable angle, to reduce possible wear. The wires can be threaded through the handlebars or door pillars, but make sure you use bullet connectors, and that they are staggered (not closely grouped) so they can be threaded through the narrow tubes more easily.

There are many ways to cut down on wiring. A popular method on trikes and customs is to use an after-market car ignition switch which has positions for run, run with lights, and starter and then placing it out of sight, often under the seat. This eliminates the need for any separate lighting or starter switches.

If preferred on an enduro, use the indicator switch as a lighting switch, or as a kill switch allowing just one set of wires on the handlebars. Be careful when using an indicator switch as a kill switch on an enduro, use the right for power so if accidentally knocked by your hand, it is more likely to stay on. See also off-road preparation later.

There are three main places to put the numerous connections from the main loom to the handlebars, inside the headlight, under the tank or near the steering head. How these wires are routed is personal preference, but if your headlight is big enough, then design the main loom so that it will go all the way into the headlight, as it's dry and easier to get to. The loom can be routed underneath the bottom fork yoke straight into the headlight, or possibly through a large enough hole in the bottom yoke of a custom show machine.

If a fairing is used, then make the connection just inside the fairing, and easy to get at. This will make the fairing or headlight pod easier to remove.

For cars, under the dash is still the most sensible central wiring area, if access is reasonable.

Where the coils are fitted under the motorcycle seat out of view, then extend the high tension (HT) leads by inserting a strong piece of wire or a small nail with both ends sharpened into the end and adding an extension piece of HT lead, then covering with glue sealant and heatshrink sleeving. On some coils, it is possible to simply unscrew the HT lead from the coil and replace it with a longer one. HT leads can also be routed through the frame if room permits. Some HT leads can be very cleverly disguised or hidden completely. Carefully choose the spark plug caps which will allow the best HT cable routing and style.

The battery should be mounted in rubber to prevent wear against the metal frame, this means some firm rubber foam around the base and sides. A vent pipe to protect your paint from the acid should also be fitted.

The tail light wiring is often found rubbing against the rear wheel, so make sure that you weld or solder small strips of steel or, if using a plastic mudguard, a well glued set of lugs or a tube inside to keep the tail light wires safe and hidden. If using a tube, use staggered bullet connectors on the wiring so they can easily pass through.

Most rear brake light switches deteriorate quickly so use good quality switch, or a type that is cheap and easy to replace.

Always carry spare fuses, as they deteriorate with time. Make sure they are the correct rating. If desperate, use domestic fuse wire across the old blown fuse, again make sure it is of the correct rating, and only use one strand of the fuse wire. In emergency, strip an old piece of wire to remove the copper strands, or aluminium foil, then use just enough to act as the fuse wire. It must be allowed to blow.

What size wires and fuses should be used ?

Each circuit will need to safely carry more than enough current for all the items on it's circuit.

For cars, double the needs for the dual headlights and tail lights. Don't forget the windscreen wiper motor and any other items.

Lights. Headlight probably 60 Watts, the dip beam usually 55 Watts, even though they are not on at the same time, but if headlight flasher is used = 115 watts. The tail light, 5 Watts. The speedo and tacho lights $2 \times 5 \text{ Watts} = 10 \text{ Watts}$, all adding up to a total of $60\text{W} + 55\text{W} + 5\text{W} + 5\text{W} + 5\text{W} = 130 \text{ Watts}$.

To find the Amps used by this example. Amps = Watts divided by Volts. So for a 12 volt system, the current in amps will be $130 \text{ Watts} / 12 \text{ Volts} = 10.9 \text{ amps}$. So for the lighting circuit we need at least 10.9 amps, but to allow a safety margin, use a 15 Amp fuse. Do not use a larger fuse than this, as it is the fuse you want to blow, not the wiring.

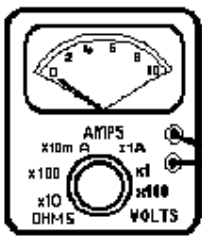
The circuit supplying the ignition will need to carry enough current for the coils, to be generous, about 5 W, the electronic ignition, maybe 5W, and the starter solenoid supply, about 5W all adding up to a total of $5\text{W} + 5\text{W} + 5\text{W} = 15 \text{ Watts}$. To find the true value, use the multimeter set on the 10 amp rating to see how much current is used.

To find this fuse rating in amps, Amps = Watts/Volts. So for a 12 volt system, the current in amps will be $15 \text{ Watts} / 12 \text{ Volts} = 1.25 \text{ amps}$. This particular example ignition circuit needs at least 2 amps, but to allow a safety margin use a 5 Amp fuse. Probably a lot less.

The ignition circuit is usually quite small, needing only a 5 amp fuse. If fuel injection is used and/or a fuel pump, then follow the original manufacturers recommended fuse rating. If in doubt, fit increasingly smaller fuses and test until they blow, then choose a fuse rating with a reasonable safety margin. When the machine is up and running, a multimeter set at least 10 amp reading and placed across the empty fuse holder, will certainly eliminate any doubts. Another way is to reduce the fuse rating until it blows. Check it is in maximum load, possibly with the fuel pump and radiator fan working, (if fitted on this circuit). The radiator fan can be run by removing the switch connectors and joining them temporarily.

The auxiliaries circuit will be the horn, about 20 Watt, Brake light, 21W and the indicators, (which are $21\text{W} + 21\text{W} + 5\text{W} = 47\text{W}$) all adding up to a total of 88 Watts. The fuse rating in amps is: Amps = Watts/Volts, so this is $88 \text{ Watts} / 12 \text{ Volts} = 7.3 \text{ amps}$. Including a safety margin, use a 10 Amp fuse. If the headlight flasher is on this circuit, add an extra $12\text{v} / 60\text{W} = 5\text{amps}$. This gives a 15amp fuse for general use.

The main fuse will handle all the above which is $130 \text{ W} + 15 \text{ W} + 88\text{W} = 233\text{W}$ Amps = Watts / Volts , so this is $233 \text{ Watts} / 12 \text{ Volts} = 19.4 \text{ amps}$. so a 25 amp main fuse is used. As not all the items will be on all the time, a 20 Amp fuse may do for initial



MULTIMETER
with probes to measure
AMPS(current)
OHMS(resistance)
and **VOLTS**

testing and just to be on the safe side while testing. Later this can be replaced with a 25 amp fuse, should it blow.

JP7

Find out the wattage of your own components and follow the above example using your own numbers. If your numbers differ widely then check again. A good quality multimeter which can measure the current up to about 10Amps will allow assessment of each individual component or the more unusual items if in doubt.

Making, Checking and Fitting the Loom.

It is best to decide where your wires are going before you do any final welding or paintwork, then you can get the brackets and any holes made early to make life easier. Always check on the final placing of all the parts such as battery, ignition switch, regulator etc. If any have suspect connectors then repair or replace, then check the part works correctly.

Where one wire goes to several places, such as the indicator switch to the front and rear indicators and the indicator light, then it will be necessary to solder wires together. This is best done where the wires are naturally split to go their separate ways, such as the indicator wire going from the handlebar switch into the main loom. These can be soldered to two wires to front and rear indicators. The indicator lamp connection would be soldered to the front wire closer to the lamp, usually where it uses a connector inside the headlight shell.

The same for ignition, where the wire splits to feed the coils and electronic ignition and perhaps the fuel pump.

Soldering the joins will mean stripping back the wire and twisting a number of separate wires together, then allowing solder to flow between all the strands for a secure connection. This should then be cleaned free of any flux and covered with tape or heat shrink. For best results, use heatshrink with an integral sealant which excludes any chance of moisture attacking the joint.

The crimping of connectors is mentioned elsewhere. Always try to use connectors similar to the original or of better quality. Gold plating is of dubious use in a harsh environment, as simple maintenance spray with a waxy film is more likely to penetrate and prevent corrosion of the copper wiring inside the insulation, were much of the corrosion occurs, not on the connectors, be they gold plated or not.

Where the ends of the loom connect to various items, there will be one, two or more wires connecting a single wire in the loom. The front indicator wire will have a double connector, to take the indicator and the indicator warning lamp connections. The ignition wire and auxiliary supply wires at the end of the loom where it enters the headlight, are often given a spare connection for later modifications. This is also done to the supply under the seat, allowing an anti theft device, or camping light to be supplied from the main fuse, or from another separate emergency fuse.

To improve flexibility around the steering head, it is useful to have the wires gently twisted inside the loom like a rope, so that flexing is more easily accommodated without undue bunching or kinking of the wires. If these wires are in a protective sleeve, then lubricate them with a little silicone grease to prevent undue wear of their plastic insulation. This is particularly important on bikes such as enduros which have a large degree of movement and high levels of stress on these wires. In extreme cases, consider

routing the wires near the headstock to run vertically for a short distance to minimise problems of flexing.

As the wiring passing the steering head is a common area for vandalism, then consider sliding a sleeve of wire netting, similar to the Chinese finger trap over this area. This will help prevent it being cut through with a knife. Such sleeving is available as copper, or preferably steel shielding on larger cables, or can be wound over the loom by hand deconstructing old throttle cable inners, before fitting the outer plastic sleeve.

In some case, there may be the need to add some redundancy into the wiring loom, such as the ability to add indicators to an enduro bike at a later date. Where necessary, it is very simple to add a few more full length wires to a loom. These should be left with their ends looped and tucked back into the loom, showing just a part of the wire, which can be coaxed out later if needed. Always tuck a good length of spare wire back into the loom, so that almost anything can be fitted. This also allows for a broken wire to be bypassed with an alternative emergency wire should a fault occur in the future.

Where needed, a set of looms can be built. Perhaps a basic loom, plus a separate loom for a fuel injection system, and perhaps a separate loom for spot and fog lights. Separate looms make maintenance much easier. Separate looms are not common on commercial machines due to cost.

For those who tour, it is often useful for an external connection for a tent light, air pump or other items. This should be a separate loom with its own fuse, allowing it to be connected from under the side panel etc, or unwound as required. Where this is fitted directly to the battery via a fuse, it can also be used to charge the battery with a battery charger at home.

Do not connect the battery yet.

Following the descriptions of each circuit as mentioned earlier, work though each circuit from battery, main fuse, ignition switch, individual circuit fuse, to switch to component etc. Do not forget the earth connections.

With everything placed where it belongs, lay the wires along the frame as intended, 'tailoring' the wires then fitting the connectors as you work through each circuit. First fit the wires to the connectors for the standard switches and other electrical components such as rectifier/regulator etc.

It is far easier to fit the reconditioned alternator with three new, long yellow wires to the bike, then to route and clip them in position along the engine and frame towards the rectifier/regulator before fitting the plastic sleeving and finally the connectors with perfect placement.

Tailoring the wiring on the bike to match the original fittings will ensure compatibility with commercial replacements. Check that the wires will not be stretched when the steering is at full movement left or right. Any wires that will go through braided nylon sleeving will probably have to be threaded through this before fitting the connectors. Always cut the wire a little longer to be on the safe side, and make sure any insulation sleeving is fitted before the crimping is done.

If wiring direct to the switches with solder joints for minimal full length wiring, as common on customs, then always work the lengths back from the fitted handlebar switches. Ensuring the full length wires can be removed through the frame. These usually all end up under the seat in the electrical box, in the headlight shell or under the tank.

Once all the wires are in place, lay them together neatly and tape them every few inches

and wherever the loom splits into two or more directions. Check the way the loom follows the frame and adjust if needed. It is important to be able to place the wiring in clips or other restraints, as a flexing loom is a problem loom.

Where the loom passes the steering head, it is best to either cover with a long length of split flexible tubing, or braided nylon sleeving to protect from any wear caused by flexing. Around the steering head, the wires should be slightly twisted like a simple rope, to prevent the wires from kinking when flexed. Unless for show, do not platt the wires, as Platting makes it impossible to use an old wire to pull a new wire into place in the loom, should one need replacing.

Finally disconnect all connectors, except the earth wires which should all be connected. Check all the earth wires between points on the frame, to the head and tail lights, to the electronic ignition unit, indicators etc. Earth wires must make a good electrical contact with the frame bolt or other fixing, remove paint if needed, then protect with grease. For carbon motorcycles with advanced wiring, there are other options under study. See later monographs or updates.

As the wiring loom is not yet covered with tape, it is still possible to make last minute changes.

Checking The Wiring Before Use.

To check the loom, assemble it all on the bike, but disconnect all components and fuses, then test the loom section by section until fully working.

There is no need to connect the charging circuit until the engine is ready to run - alternator and regulator etc.

Starting at the fully charged battery, connect the main fuse. Connect the bulb and croc clip to the return from the ignition switch to the three fuses, it should light only when the ignition switch is on. Check the ignition switch in all positions. Then insert each fuse to check each circuit in turn, again using a simple bulb or multimeter.

Connect up the kill switch and connect the croc clip between the coil connectors and earth, if the bulb lights, when the kill switch is in the 'run' position then the kill switch works. Test power goes to the electronic ignition connector in the same way. Do not connect an expensive electronic ignition unit until the kills switch works correctly.

Check the bulb goes out when the kill switch is off. Fit the electronic ignition components then the engine can be cranked over to check for sparks. If a strobe is available, then the ignition timing can also be initially checked. This can be done using the kick-starter or with jump leads onto the starter motor.

Likewise check the lighting and auxiliary circuits in a similar manner.

Give the switches many on and off cycles to check they work reliably, as they may work after standing for a year, but may fail quite quickly if dirt or corrosion has occurred during storage. Work your way through until any fault is found. When any part fails to work, remove the fuses to the other circuits, then safely work on just the one circuit at a time.

If problems occur, then work back and forwards along the wire to the problem. Use a simple bulb with two wires and croc clips. Connect one croc clip to the negative side of the battery, the other croc clip to the main fuse holder. If the bulb lights up then all is OK so far, then work towards the fault, reconnecting each item as required.

When problems occur, check the earth return wires to frame and the battery are making good connections. Connect the bulb between the battery positive and the earth wires to

check the earth connections to the frame. Work though logically until sorted.
The charging and ignition circuits can only be checked against the wiring diagram at this stage, double check that they are correct according to the diagram and that you know how they work.

If confident, disconnect all other fuses and only connect the ignition circuit, then switch on the ignition switch and put the kill switch to run. Then check the electronic ignition for excessive heat, use a finger and also sniff for burning smells.

If the engine turns over you can check for a spark at the plugs, although when using a less than fully charged battery for starting, the spark may be weak.

If you have points then you can check for a spark at the plugs simply by opening and closing the points manually or with a screwdriver across the open points, and watching for a spark. Adjust the ignition timing so the points just open at the F mark.

Once the sparks work, use the kill switch to prevent damage to the coils and electronic ignition box.

The charging circuit can now be connected. The alternator, rectifier / regulator and any field coil or sensor wires.

Checking The Whole System Under Working Conditions.

With the basics on the bike, plus fuel in the float bowls, or fuel pump supplying the injectors, check again that all the parts work. Connect a volt meter set to read about 20 volts across the battery, it should read 12 Volts.

Start the engine, if the battery voltage rises to around 13.5 to 14.5 Volts, then the charging circuit is OK.

If it stays at 12 Volts or lower after a short while, then the charging circuit is not working. Check the connections and that the alternator white or yellow wires supply AC by connecting the multimeter across any two white or yellow wires and starting the engine again. Check with the meter set on the 25volts AC range.

If AC is present, around 20 to 40 volts AC between each of the three yellow or white wires, suspect the rectifier/regulator unit.

If the battery voltage while running is less than 13 volts then suspect the alternator or the connections or regulator/rectifier unit.

If the battery voltage while running is over 16 volts then suspect the regulator. See sect 3.

On smaller bikes with just one alternator wire to the diode leading to the battery, check for AC between this wire and earth, such as the crankcase. On 6volt systems, the battery voltage should rise to 7.5 volts while running.

What Can Go Wrong.

No electricity, the bits work wrongly, too much electricity, bits smell or even melt and fuses blow.

First is the engine does not run. Check the ignition timing with a strobe.

Check the coils to cylinders 1&4 and 2&3 are connected correctly. On many motorcycles, simply swap the plug leads, or low voltage wires to the coils.

On cars, make sure the HT leads from the distributor go the correct spark plugs.

It is possible to get parts mixed up and put a six magnet rotor on a four pole stator or vice versa, so always keep the rotor and stator as matched pairs unless you can feel the magnets and count up to six.

If a totally different electronic ignition box is used, then check the ignition timing with a strobe, as the pulser coils may be wired back to front, requiring the pulser wires to be swapped to give a N-S instead of a S-N magnetic pulse.

Refill the float bowls and try again. When running, check the battery charging again.

Wiring problems are mainly due to the wrong connection of wires, so the use of an easy to follow colour scheme is important. The problems can be divided into various types, no electricity, where parts don't work, too much electricity where bulbs blow or parts get hot or melt, or intermittent, where parts fail only occasionally.

Fuses will prevent most problems from getting worse. Unfortunately this can lead to the cost of using too many fuses, especially if an old loom has been poorly repaired. For cheap testing fuses, it is best to strip some spare wire then use an appropriate number of strands to mimic the fuse until all is well. A few strands will often do, and can be placed across the fuse fitting, jammed in position by a blown fuse. This will still do the job, saving a lot of cost if problems persist.

No electricity is due to either an open circuit where the circuit to the battery or to the earth is broken. Check this using the bulb with crocodile clips, one clip to earth and the other clip connected to the circuit at each join in the circuit. Start from the battery, working through the circuit until the test bulb doesn't glow, the fault is between this and the last connection. All too often a broken or corroded wire, a corroded switch or connector, or a bad earth on the mounting bolt.

All earth connections should make electrical contact. If fresh paint is applied, scrape off for a good electrical contact, and use a little grease to protect from rust.

Too much electricity with the engine running will be due to the excessive voltage caused by a damaged, or possibly partially connected or unconnected regulator, so check for correct connections to the unit and to the alternator. Some regulators may have a sense wire (see above and later) connected to the auxiliary or ignition circuit and if it is not connected, then it cannot tell the voltage on the bike and so cannot regulate it.

If components blow without the engine running then they must be the wrong voltage such as 6v bulbs on a 12v system, or have delicate internals such as electronic ignition units which have been wrongly connected. Be aware for burning smells and hit the kill switch. In some cases, double check if the fuse has a larger rating in amps than it should have.

Intermittent faults are difficult to find, so when they happen, take careful note of what the bike is doing when it occurs, such as rain, or only when the handlebars are turned one way, over a bump in the road etc. From this information you will have to decide what is causing the problem and then try to reproduce it by moving/shaking/stretching the wiring while looking for the fault to appear.

On rebuilt looms, look out for loose or corroded connections, or if the loom is old, then suspect any soldered joins inside the loom where poor soldering can cause the wires to part. This can happen even in bikes only a few years old.

If problems are time dependant such as failing after a few minutes, then suspect worn points or condenser, poor contacts, corroded or poorly made connectors, overheating or tired electronics.

When charging correctly, then reconnect the circuits one by one and then test as if riding. Run the engine and turn the handlebars fully, bounce up and down on the seat to

see if any parts underneath rub or any other problems occur. If it's a dirt bike, waterproof the connections fully, then hose the bike with water while running. Then dry the loom fully and again waterproof the connections fully before taping up. Spray silicone spray into each connector, wipe any excess off, then seal the connectors with silicone sealant or bathroom sealant where the wires enter the connector, then spray the connected items with hair lacquer.

If all is well, the loom can be taped up fully. Start at the ends nearest the connectors and tape over any plastic sleeving so that it wraps tight about the wiring. Finally tuck in any ill fitting wires and tape up the centre section.

Main areas of long term concern are the tail light wire rubbing against the tyre, the main loom around steering head, and water getting into any soldered joins deep in the loom. Tape up the loom so water cannot get inside, to reduce possible corrosion and failure at a later date.

When riding for the first few hundred miles, carry a set of spares and tools.

SECTION 3.

Reference section.

Wire sizes for safe current loads. For normal use on motorcycles you need only use four sizes of wire, a special starter cable, High tension leads (HT) for the coils to the spark-plugs, 17 amp wires or larger, depending upon the bike, for the main battery and ignition switch to fuses and if you are using a lot of extra electrical parts such as fog lights etc. Also 8.7 amp wire for the rest. Approximate numbers will do.

The following gives details of the normal wires used in vehicles and the safe loads they can carry in amps.

The first number is the number of strands of copper in the centre. The second number is the diameter of each strand, the third number is the total cross sectional area of the copper strands in mm squared, and finally the current it can safely carry in amps.

Commonly used wires are:

9 / 0.30 , 0.65mm sq , 5.75 Amps
14 / 0.30 , 1.00mm sq , 8.75 Amps
28 / 0.30 , 2.00mm sq , 17.5 Amps
44 / 0.30 , 3.00mm sq , 27.5 Amps
65 / 0.30 , 4.5 mm sq , 35 Amps
97 / 0.30 , 7.0mm sq , 50 Amps
120/ 0.30 , 8.5mm sq , 60 Amps

Starter and Earth cables.

These cables have to carry a great deal of current when the starter is used, and so they need to be particularly thick. They should be made up with the appropriately larger size of terminal at each end to fit the bolts which secure them. If you have to make your own, then get cable similar to the original, which will do for most bikes. Strongly crimp or solder the large terminals to the ends, as these can get hot if they are not making a good electrical connection. Do not be afraid to gently hammer the clamp over the copper strands to make a good solid connection. For a better fit, the end of the tag can be heated in a flame while solder is introduced to make a good electrical join.

For a little flair, tinted or clear silicone speaker cables can be used for smaller electric start machines, but must be protected from heat or friction. These cables often have

many fine wires, making them more flexible.

If (like a recent project), you are fully rewiring a five litre fuel injected V12 trike, then consider using high spec welding cables for the starter motor and earth connections.

Placing the battery close to the starter will also help.

The following is a typical shopping list for a Japanese four cylinder bike wiring loom.

This is only an example and all numbers are approximate.

Colours given only as an example, using Red to supply the main current, White for the lighting circuit, Blue for the ignition circuit, (big blue spark at the plugs), Orange for the auxiliary circuit, (usually associated with the indicators) and Black for the earths. These are merely the authors preferences, and everyone will have differing associations with colours.

Always follow the original manufacturers colours if possible, or if a special or custom, choose your own wiring loom colours. If in doubt, the following makes for a reasonable wiring loom.

The following wires are 44 / 0.30 , 3.00mm² , 27.5 Amps

1 metre Red rectifier/regulator to battery.
1 metre Red battery to main fuse.
1 metre Red main fuse to ignition switch.
1 metre Red with white tracer ignition switch to the three other fuses.

The following wires are 28 / 0.30 , 2.00mm² , 17.5 Amps

3 metre Yellow Alternator to rectifier/regulator.
1 metre White fuse to lights sw.
1 metre White with blue tracer..... lights sw to high/low sw.
4 metre Black..... earth connections to frame.

The following wires can be reduced to 14 / 0.30 , 1.00mm² , 8.75 Amps if preferred.

1 metre Blue..... fuse to kill switch
2 metre Blue with white tracer..... kill sw to coils and electronic ignition unit
2 metre Orange with red tracer..... fuse to brake sw to brake light.
2 metre Orange with white tracer..... fuse to switch to horn.
1 metre Orangefuse to flasher then to indicator switch.
3 metre Orange with white tracer indicator switch to left indicator lamps.
3 metre Orange with black tracer indicator switch to right indicator lamps.

The following wires can be reduced to 9 / 0.30 , 0.65mm² , 5.75 Amps if preferred.

1 metre White with green tracer..... lights sw to speedo
2 metre White with red tracer lights sw to tail light.
1 metre Red with black tracer..... starter button to starter solenoid.

2 metre orange with blue tracer neutral light.

2 metre Orange with red tracer oil warning light.

Other wires as required such a water temp gauge, radiator fan etc.

Connectors.

50 x Bullets 3.9 mm (male).

40 x Bullets 3.9 mm insulation.

40 x Bullet sockets 3.9 mm. (female).
30 x Bullet sockets 3.9 mm. insulation.

10 x Double Bullet sockets 3.9 mm. (female).
10 x Double Bullet sockets 3.9 mm insulation.

5 x Triple Bullet sockets 3.9 mm.(female).
5 x Triple Bullet sockets 3.9 mm insulation.

Quadruple female connectors also available if required.
(It is simpler to buy just the triple connection sockets instead of double connection, as this gives more adaptability to the loom at a later date.)

A selection of multipin housings also required if not re-using original bike connector housings. These can be new, or recycled using just the new internal connectors.

50 x Male blades 6.3 mm. with latch (locking tabs) for multi-pin mouldings.
50 x Female blades with latch for mouldings 6.3 mm.

25 x Male blades 6.3 mm.
25 x Male blades 6.3 mm insulation.

25 x Female blades 6.3 mm.
25 x Female blades 6.3 mm insulation.

25 x Double crimp ring terminals, 6.4 mm diameter holes.
2 metre Starter cable black 37 / 0.71mm.

4 starter cable ends with 6.4mm holes.
1 metre of Heatshrink tubing, 6 mm dia .
1 metre of Braided sleeving or split corrugated plastic tubing 12 mm dia for steering head area protection.
2 metres copper cored HT lead. (4 metres on customs with coils mounted under the seat.)
5 x 30 amp fuses.
5 x 25 amp fuses.
5 x 20 amp fuses.
5 x 15 amp fuses.
5 x 10 amp fuses.
5 x 7.5 amp fuses.
5 x 5 amp fuses.

This may seem a lot of fuses, but it is common for many first attempts at making a wiring loom to get through a rather large number of fuses. It may be cheaper to buy a box of assorted fuses.

A set of circuit breakers may be preferred, and are now available to fit into standard blade fuse holders.

Original or replacement fuse box.
4 rolls electrical insulating tape.
Selection of heat shrink tubing.
1 Crimping tool for insulated (or uninsulated) connectors.
Butane soldering iron and solder. (Mains or 12v soldering iron will also suffice.)

This is not a perfect shopping list for all machines, but is typical of what is normally required. The wire colours and types of connectors are the main areas of difference and will depend upon the machine.

It may be preferable to replicate the original wiring colours as used by the manufacturer of the bike.

Checking The Internal Wiring Of Switches And Components.

When rewiring the switches and other components, it is often very important to find out how they are wired inside. It is also preferable and highly recommended to do so, if only to check the condition of the internals.

Another good reason for delving into switches is to rebuild or modify them to suit personal preferences, such as reducing premature wear or corrosion, or ultra light weight direct wiring, or for direct wiring connections under the seat.

Three ways are possible to understand the internal workings. Using a multimeter, taking it apart, or reading the original manual. The block diagrams found on many user handbooks supplied with the machine are ideal to show the many connections of the ignition switch in it's various positions. Particularly useful where many wires may be fitted.

Most other switches are much more simple, and should be simply looked at while stripped.

For all switches, look for corrosion and cracks. Go carefully, some parts are easy to break. New or custom components can be made with a little effort. The simplest is the plastic indicator button being replaced with a sculpted alloy item to match the styling of the rest of the machine. Alloy can be easily anodised in a plastic cup, using battery acid and a battery charger. Anodising can be done in many colours. See other monographs.

On rusty items, apply penetrating oil on screws prior to stripping switches. Where the handlebar switch outer casing securing threads have stripped, it is possible to fit a length of stud bar deeper into the stripped thread, secured by epoxy resin or stud lock. A nut and possibly a spacer can then be used to secure the switch onto the handlebars. This will often require a narrow socket or fitting a spacer tube between the nut and the housing.

As all switches contain small parts, take them apart carefully. Look out for springs and small balls disappearing. If in doubt, disassemble the switch inside a large clear poly bag, so you can see what you are doing, and should anything spring out, it will not get lost.

The plastic parts of switches are delicate and can break. Levers or knobs not held by screws may be carefully eased off using a flat blade screwdriver under the plastic stalk. If in doubt, buy a few scrap switches and practice first.

The internal connections are often more easily understood when disassembling switches. If the switch is complex, then simply remove all extraneous wiring and simply solder in just enough to do the job.

It is preferable to clean the brass inserts base strips after the wires are soldered in place. This gives a smooth finish by rubbing gently using fine wet and dry paper on a flat surface.

Always check the springs and balls, especially on older switches. If in doubt, replace or apply silicone grease to prevent further corrosion. Always make sure any contacts such

as the starter and horn concentric springs are properly seated for a good electrical contact. If the switch is beyond hope, a small commercial electrical switch can often be fitted in the same space, with a little fitting and trimming work.

All ignition switch wires that end in soldered joints can be desoldered, allowing total redesign of the way it is used. But always make a note of which wire goes where and what they do. Use the note pad. If there is any corrosion, then this is the best time to remove the base containing the electrical contacts. Clean using fine wet and dry paper on a flat surface. If necessary, this is a good time to de-solder the original wires and fit new wires. It may be preferred to leave the free ends of the wires so they can be trimmed and fitted to connectors when later 'tailoring' the loom to the frame. Unless an extreme custom, the best solution is to keep the ignition switch and other items as standard as possible so that replacement is easy.

Ignition switch repair.

The ignition switches of bikes and cars are almost always a rotary plate on a disc with contacts placed around it.

Before the base is removed, be very careful to keep the parts positioned the way they came apart. ALWAYS mark how they fit together first by making a scratch across the adjoining parts.

Also mark with a scratch, the thicker (usually red) wire connection, supplying the current from the main fuse before rewiring. This will ensure all other new connections will act correctly when refitting with new wires. The base of the unit which contains the switch part, can be carefully opened by either bending back the metal tabs, or sliding very small screwdriver blades between the sides and the base. This is tricky and may cause the casing to crack, so always use very fine screwdrivers or use three flattened paperclips. If cracked, then wrapping with tape or gluing may effect a reasonable repair. Some of the internal spring-loaded contacts have three pimples, and must be fitted correctly, so check during disassembly, always mark them. Where springs or other components are corroded, it may be possible to salvage from a similar discarded component. Remove corrosion from the rotary base by rubbing on wet and dry paper on a flat surface, until all corrosion is removed, then just slightly lubricate surfaces lightly with maintenance spray or otherwise leave them dry.

If modifying the way the wiring is connected, then this is the best time. Desolder the wires and decide which connections to use, and in which key positions they are connected, and just as important, which positions they are not connected. Make sure they don't leave the ignition on when the key is removed. Clean the contact face with fine wet and dry on a flat surface after the soldering, as some distortion can occur with the heat.

Use a multimeter set to ohms resistance to check in each switch position. When a replacement switch is needed, the modified base and it's custom wiring can often be simply be fitted or copied to the replacement, if the internals are otherwise identical. The best choice is the type of ignition switch which has a switch unit retained by screws to the lock section. This will allow a custom or modified switch unit to be easily fitted to a replacement key lock after vandalism or if the keys are lost.

When modifying an ignition switch, never try to put all the current through a single contact. It is common for most ignition switches to allow two or three main supply contacts, so the wear on the internal contacts can be spread more easily. Putting all the power through a single contact will soon cause wear, wear leads to corrosion and corrosion creates a resistance which causes heat, leading to premature failure.

Although not always possible, try to spread the power through as many contacts as possible. The main wire from the main fuse can be split at the base if the ignition switch to supply two or three contacts which can then supply the ignition, auxiliary and the lights, depending upon the internal configuration. This leads to much greater long term reliability.

The tumblers in the lock can be removed on some types and is not as much trouble as one may think. Consider trying, perhaps after vandalism causing damage to an otherwise good switch. Use an old switch first for practice. Remove the easier parts then tease back the circlip or brass pin which keeps the barrel in place. Fit the key and slide a very thin screwdriver or flattened piece of wire between the tumblers and barrel to remove the barrel. Keep the parts from other switches, to rebuild the unit to match any key which will fit the profile grooves inside the barrel.

Rebuild in a reverse manner and use graphite powder to lubricate the non electrical parts, or a rub of a pencil lead will do. Do not use graphite on the electrical parts. With three scrap switches, it should be possible to disassemble and repair them enough to be a reasonable expert before attacking the proper ignition switch and key tumbler mechanism.

WARNING. If the ignition switch is a modern type with super expensive, electronically coded key overkill, then simply consider replacing it with a practical replacement. If the switch also codes to the engine management system, then a delicate approach should be employed and a specialist employed who can directly override or circumvent the coding.

In the worst possible scenario, it may be better to simply leave the key in the lock so that the ignition system works the engine management system then poly bag it to keep it dry and tape it up somewhere convenient and hidden, then simply use a second, standard ignition switch for the other bike or car electrics.

The fuse box.

Use a decent fuse box from a motorcycle, they are available from breakers or as new spares, and are often much better than the types for cars.

Fuses: There are continental type fuses, which are rather tacky, traditional glass tube fuses in either imperial or metric fitting sizes, blade fuses, and trip fuses. Main fuses now also supplied as screw-in metal strips on motorcycles, and as a fusible link in the battery wiring for cars.

As many custom builders have a reputation for poor wiring, consider self - resetting, or resettable thermal fuses, which will reduce the number of blown fuses from poor wiring until the fault is found. These are common in Harleys.

The lights switch.

This is usually a one or two way switch, if two way then the first position is for the tail and parking lights, the second position includes the speedo and the main / dip switch as well. Check internal connections.

Note: On many of the larger Suzuki's (1980's) there is also a second switch working off the lights switch. This is a double pole, single throw switch. One side works the lights on / off, the other part of the switch connects one of the three white wires from the alternator to the regulator, and must be connected to the alternator/rectifier wires according to the manual, as this keeps the rather basic charging levels correct.

The high/low beam switch.

This is a simple two way switch taking power from the lights on switch to the hi/lo beam. This is usually a fiddly job to get neat solder joins to the switch, but a full strip can enable a neat job. Where possible, the wiper face can be smoothed with wet and dry on a fat surface after soldering.

For internal convenience of wiring, it is common to fit a wire from the auxiliary fuse to the headlight flasher switch, which then connects to the high beam connection. It is usually a short extra internal wire in the switch housing from the auxiliary fuse supply from the horn button. Usually accomplished by two short, simple wires inside the handlebar housing.

Where the switch has a push fit lever onto a plastic stalk, then great care must be taken to pull this item off evenly without damage.

Indicators.

The indicators switch is just a simple three position switch. Check for corrosion and dirt and solder new wires if needed. Check the action, and that the central 'off' position is easily found. This may require cleaning and lightly greasing the detent section of the switch.

The indicator switch unit often collects dirt and moisture, requiring reasonable drainage. The indicators switch may contain extra contacts which switches them off after a set distance, often measured by a number of pulses from the speedo from a reed switch near the speedo magnet, using a separate box of electronics. Where a complex set of connections is involved, just the basic part of the switch can be used and the rest ignored or removed. This can be done by simple desoldering. On some modern cheaper items, the connections are simple push-fit wires, which can be difficult to remove, leaving a poor electrical and physical connection.

The starter button and horn button.

This is a simple push to make switch, and the only problem is if the contacts get corroded or dirty, or if the spring rusts and collapses. This can be replaced by a small simple push switch from electrical retailers. Replacement springs can be made from modifying springs from similar switches.

The horn switch simply connects the wire from the horn to earth or connects the wire from the fuse to the horn. If there is only one wire to the switch, then make sure that the other side of the switch will make a good earth contact on the handlebars. Corrosion is the main culprit, solved by cleaning, paint and then a little protective silicone grease.

A little thought in the handlebar switches can reduce the wire count significantly. Likewise for car dash and other switch wiring.

Car switches are usually built down to a price, making some motorcycle components look positively overbuilt. The plastic and stamped metal inserts need a lot of careful disassembly and is often a puzzle to find the safe way to disassemble.

Once apart, carefully clean all the contacts and lubricate lightly with silicone grease where appropriate. Other contacts can be cleaned with fine or worn 'wet and dry' abrasive paper. When the plastic lugs have broken off, prefer to use non permanent methods of repair, such as adhesive tape rather than glue.

Where springs have corroded or broken, it is possible to make new items or modify similar items. The authors screen washer button uses a home made spring from a paperclip.

Typical problems with switches.

Springs get rusty and fall apart. In such cases, use springs from similar switches or from other sources such as retractable pens, or other small mechanical componentry.

Corrosion. This requires basic cleaning, and if still beyond hope, then a new switch may be needed.

Broken lugs or levers. Always be extremely careful to tease apart any delicate or old plastic component. These are often the hardest to repair, but if an irreplaceable classic component, then they can be repaired or rebuilt in epoxy resin or 'plastic metal'. In extreme cases, they can be carved from nylon block or other plastic, using small modellers drills, needle files and a sharp scalpel.

Where there is a stripped threads in the metal housing, use a stud bar, which is a long threaded item. This can be screwed fully into the stripped thread hole, also using machinery adhesive to make the most of what thread is left. Nuts can then be used to retain the housing. Where there is not enough room for a nut, the use a spacer and a nut. If no stud bar, simply cut down a long threaded screw or bolt.

When replacing wiring to the switch components, use just a small blob of solder with a short exposed inner wire to be soldered onto the switch. It will be necessary to carefully fit the wires inside the housing, to prevent damage from being caught when the casing is in place. Where the wires exit, they must be retained from being pulled out, by using the original internal retaining plates.

The starter solenoid.

The motorcycle solenoid is either works or is replaced or repaired. To check, simply connect the small wire to the positive side of the battery, and the earth wire or casing, to the negative side, if the unit makes a good solid click, then it should be OK.

If the type has the main fuse on the side, then check that this is in good condition, and that the special type of spare fuse is available.

A total solenoid rebuild may require de-soldering the wires that hold the cover for the solenoid coil. Most repairable faults are corrosion on the copper main contacts which can be cleaned or reversed. Small bikes may use a heavy relay in a rectangular box, which is easier to repair. If it's to be scrapped then have a go, there is nothing to loose. Most solenoids can be used on bikes of a similar size.

For cars, the solenoid can be disassembled, cleaned and repaired, but a reconditioned or replacement is often far cheaper than imagined.

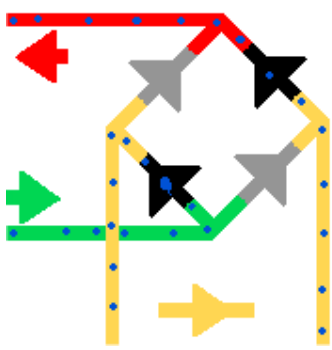
Starter motor.

The starter motor should have alignment lines on the outer casings, if there are none then scratch some so that the casings will align correctly when reassembled.

Wear is normally only on the graphite brushes and the ring of copper strips of the commutator. The commutator can be very carefully smoothed down using a strip of fine wet and dry paper. Use the absolute minimum cleaning required. Do not attempt to remove metal, just to clean the surface of major imperfections. Make sure it remains perfectly circular, with little or no dirt between these strips. If there is dirt, then very carefully clean a shallow groove between each copper strip using a tooth pick or a thin piece of hard plastic.

The graphite brushes which rub against the commutator must be checked for wear as they may become too short. Replacements are usually available.

Also check if the brush springs have become weak through overheating. Look for burning or melting of the insulation. Sniff. Clean gently and thoroughly, then lightly lubricate bearings.



If the machine has high compression pistons with hairy cams, the motor may not be strong enough to crank the engine easily. This may be due to a poor battery or an ordinary starter motor which is not quite up to the job. If the starter motor struggles, the springs on the brushes may be made slightly stronger. This will push the brushes a little more firmly onto the commutator to 'dump' more current for a higher torque which may help. This is not recommended unless the battery is up to the challenge, and that the owner expects more wear on the commutator and that the starter motor is not run for too long, allowing it to cool for a while between attempts to start. If the starter motor is replaced with a higher spec item, the old one can often be rebuilt or modified to take more power using fewer turns of thicker wire in the windings.

The tail light.

The bulb holder can be rebuilt with long wires if needed, by soldering wires directly to the central contacts where the bulb fits. The earth can be soldered to the bulb holder casing, or to a suitable mounting bolt to give a good earth connection. If the bulb holder is pushed into a rubber mounting, solder to the housing or simply wrap a few turns of the earth wire around the housing before inserting the mounting. Use contact adhesive to reduce corrosion.

Long wires allows simpler fitting with connections only needed under the seat. This is done to allow easier and more reliable fitting and cleaner lines. Most three-core domestic flexible cable does the job perfectly. If soldered directly, a long length of domestic three core wire the tail light can be connected directly under the seat, fuel tank or even in the headlight shell. Direct wiring from the tail light to the headlight shell is ideal for dirt bikes if just the front brake light switch is used, allowing the tail light to connect almost direct to the right hand switch unit which usually contains both the brake switch and lights switch.

The rectifier / regulator.

If the regulator/rectifier is in one unit, then check for corrosion of the yellow or white wires which connect to the alternator and an earth and the large red to the battery. (For early four cylinder Suzuki's, see also lights switch.)

On old machines the rectifier may be a set of plates with little round diodes on them. If hard to find, these rectifiers can be replaced with modern equivalents. To check the continuity of the diodes, use a multimeter set to ohms resistance. Connect the multimeter probes across any two yellow or white wires which should show a reading when the probes are connected one way, and no reading the other way. If it has two yellow wires then can only make one check each way, but with three wires you have to make three checks each way.

The regulator may be in an aluminium finned case and keeps the voltage at 13,8 volts (or 7.2 volts), when the engine runs. If it does not keep the voltage correct, then check for good connections or consider replacement. If the unit has a field coil or a sensor wire, then check these connections before condemning the item.

Unless specific details are available from the correct manual for the bike, then the regulator unit may only be checked when the engine is running. Check by reading the battery voltage before running the engine, (12volts or 6volts) and then check with the engine running, the voltage should rise to around 13.5 to 14.5 volts (or about 7.5 volts on a 6volt system). Then put on the lights and check the voltage does not drop below 13 volts.

If the alternator has a field coil, then there will be another wire to this as well as the two or three yellow or white from the rectifier. If fitted, a field coil can be checked by removing the alternator cover. If it has permanent magnets on the rotating part (which strongly attract steel or iron tools) then you don't have a field coil (a field coil is needed to make this magnetic field, hence the name). The field coil looks like a big bobbin of copper wires in the centre of the alternator. To check the field coil simply connect the multimeter probes to the wire to the field coil and the engine cases, if there is continuity in the circuit with a little resistance, then the field coil should be OK.

Check the connections and wiring from the alternator, as they sometimes rub against the exhaust causing wear and failure. Buy a few more metal tags which fit under the casing screws to keep these wires safely retained.

On a few regulators a special wire may also go to the main loom to 'sense' the voltage in the loom, so that it can keep the voltage constant. Some machines used a smaller black wire for this purpose, and it should be connected somewhere between ignition switch and fuses, but not between main fuse and ignition switch.

Some earlier alternators may have carbon brushes rubbing against a copper track, check the track, brushes and all wiring for damage. The carbon brushes may have worn below the recommended limits.

If replacing the wires from the alternator, then find the soldered joint where the wires join the enamelled copper wires wound inside the unit, and replace one at a time making sure any insulating sleeves or metal tabs are replaced as found. If the wires go through a plastic grommet in the casing, and the alternator runs in the engine oil, then use a good general purpose glue to make an oil tight seal.

If a small bike, follow the original wiring for the bike which may use a specially wired alternator/generator and a specially wired ignition switch. Such set-ups may often use one of many devious methods for getting the most from a small electrical system, with subtle, yet often simple methods.

Where the machine has slid down the road, the outer casing may be trashed, or in need of repair, and the windings may be in need of a little careful attention. If lightly grazed, the windings can be teased straight and lacquered for re-insulation. If the copper winding has lost more than a third of its thickness, then it should be wound back to decent wire and reconnected. Losing a few percent of the winding is not nice, but can manage to work. If problems occur, then simply count the number of turns when unwinding, then buy new lacquered copper wire of the same size and neatly rewind. The final few turns can be retained using a wrap of epoxied cotton cloth.

Car type alternators can be easily disassembled and new bearings, rectifier pack and brushes cleaned or replaced as required.

Electronic ignition.

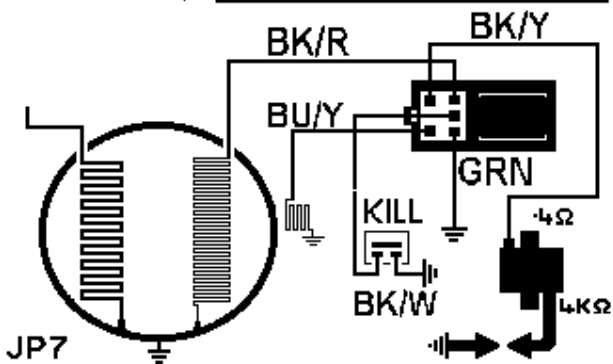
Look for corrosion or damage. Keep all the wiring as standard wherever possible and never rebuild any wiring without making notes of where each wire goes and what it does before repairing it. If this is followed, then simple replacement or lengthening, shortening of the wires, or replacement of the multi pin connector is all that should be needed.

Even the computer unit of a fuel injected V12 trike can be rewired without hassle if taken carefully.

Unless you have specific details from the correct manual for your bike, then the

C
90

BK/W	KΩ	5W	EXT	PC	E	IGN
BK/R	5W	.	.	∞	∞	∞
BU/Y	EXT	1:10	.	∞	∞	→
GRN	PC	5:200	5:50	.	1.5	∞
BK/Y	E	2:30	1:10	∞	.	∞
	IGN	∞	∞	∞	∞	.



electronic ignition can only be checked when the engine is running. Check the quality of the spark, and check any electronic advance if fitted, by using a strobe when running.

An otherwise good electronic ignition or regulator/rectifier unit may succumb to corrosion and the little flat blades on the unit may break off, leaving only a small piece visible. If this happens, then try cutting away some of the plastic around the remains of the pin and then solder a good piece of solder to the stub. Then solder a replacement wire to the visible

part. Fit the multipin connector on these wires soldered to each connection so that can then fit the wiring loom as usual. It is worth sealing the repaired connections to the unit with epoxy resin to prevent further corrosion and to give some protection from the wires breaking away should the soldered joints be marginal. A similar epoxy or silicone bathroom sealant approach should be taken for ISDE and similar heavy abuse systems, plus a secondary quick replace backup unit. If using silicone sealant, a clear version will allows visual examination over the following years.

For most two strokes, the electronic ignition does not need an advance and if connected appropriately, then a Honda C90 CDI unit will work quite happily on many machines. This is regularly employed on an NS125 and Yam RD/TZR engines, and for most other similar bikes including mopeds, scooters and motocross. Likewise many other systems. The drawing opposite shows a basic set-up.

If a mechanical advance and retard is used on the bike, then almost any CDI will work. A points system can be upgraded using the pulser unit in place of the points, with the advance retard cam shaped to a square edge with a small airgap between this and the pulser unit. As the cam passes by, the magnetic field in the pulser is interrupted and may often work the 'bodged' CDI system using easily available scrap components from common machines. Some cams are magnetic, so may not work on some machines, or need to epoxy a small shaped magnet.

All systems supply the same spark across a spark plug. There is no real magic. Little is lost in trying to fix, bodge or re-engineer an already failed ignition system.

See also authors website with 'A simple alternative electronic ignition for motorcycles', describing how to use the above Honda C90 CDI unit on a typical two stroke. The only problem with a recent TZR was needing to reverse the pulser wires to get the correct ignition timing and an alternative exhaust valve controller.

Electronic ignition pulsers (pickups) which pick up the crank position, need a small air gap between the pulser and the crank or flywheel marker. As this is often magnetised, iron dust may be picked up and cause problems. Always clean and make the airgap as intended by the manufacturer. Half a millimetre approximate gap if no data available. For those refining their timing, the airgap can be slightly adjusted.

The advance/retard unit.

This consists of two weights which are retained by springs. When the unit spins, the weights move outwards, causing the central cam to rotate slightly, under control of the weights and revs. The spindle may become stiff, so mark the parts, strip, clean then lightly grease before rebuilding. Do not use a grease which will harden with exposure to

heat. The springs may become loose or worn, so only tighten up any slack in the springs just enough to remove any slack. Excessive spring modification will probably damage or modify the advance curve. This should be checked with the engine running, using a strobe. Adjust springs, weights and end stops to modify the advance curve of a modified machine.

Cars also have a vacuum unit which adjusts the timing at low revs, and this should be disconnected when setting the timing by strobe. The simple vacuum linkage needs only to be easily moved under the vacuum from the inlet manifold, but not sloppy in action. Light friction springs are used to hold the rotating base unit so it can turn. Lightly grease the base plate to prevent rust.

If a special machine is being built, such as removing the alternator and its pick ups to take a different power take off, then a similar pickup set-up can be mounted elsewhere. Alternatively where a mechanical advance retard unit is required, perhaps to be able to change the advance curves then a standard unit can be fitted to the end of the camshaft, by employing a unit from a camshaft driven design of unit. Many camshafts can be extended, by tapping a threaded hole into the camshaft to run true, plus the alignment pin hole, fitting the unit and carving the head and rocker cover to fit a standard oil seal which can take a little mis-alignment in the casing. Then the pickup housing can be carved to fit as required, often requiring a machined spacer extension on the central bolt so the housing can be fitted easily. (Recommended on early 860/900cc Ducati V twins.) Such primitive devices allow the builder to modify the advance curves in many ways and make tuning much easier. This has been superseded by electronic systems. On some systems, the rider can adjust timing, dwell, curve, steps and such like using real time adjustments with buttons and read outs, but is better done with rotary pots while riding or on the dyno until ready for 'hardwiring'.

The Points.

These are switches which are activated by the position and speed of the crankshaft, using the advance/retard unit. The only wear is damaged screws, and pitting of the points.

The points can be dressed to a smooth slight dome shape, which can be done many times. Check for neat and tidy wiring leading to the points, and neat internal wiring to prevent the wires from failing or rubbing against other components.

The first adjustment to make is the gap between the contacts and is set when the contacts are at their widest. The gap is usually 0.6 mm or check your manual.

The second adjustment is the position of the points around the crankshaft, which controls when they open. This is best checked accurately either using a 'strobe' light with the engine running, or with a bulb and crocodile clips. Connect one croc clip to the points spring, and the other croc clip to earth. With the ignition off, turn the engine slowly in the direction it normally rotates until the 'F' mark on the advance/retard unit lines up with the mark on the engine casing. At this point the bulb should just be at the point where it is just about lights. If not then adjust the position of the plate holding the points until the bulb is just lighting. Turn the engine over slowly again and double check.

Where it is possible to rotate the cam without scratching it, then advance the cam fully to check the fully advance marks, which are usually two lines 'II'.

All modern points backing plates have a screwdriver slot to allow easy adjustment. Slacken just enough to adjust the points, but not enough to allow the points to slip. Tighten fully after adjustment, then double check, as tightening can upset the

adjustment.

Most of the small screws are often damaged, so always use a good screwdriver and replace the screws when worn, as they are very cheap. Never over tighten the screws, as they may strip the backing plate. If this happens, a temporary repair can be done by threading a screw from the rear, then soldering it in position and dressing down the head so it does not foul the advance unit, and then using a nut and washer on the front.

For those with good eyes, the points can be seen to just open by rocking the crankshaft by hand, then holding this position to compare with the timing marks. Works surprisingly well.

The condenser can only be checked visually for damage. The condenser either works or does not. If problems persist or excessive pitting of the points occurs, the condenser should be replaced.

Ignition coils.

The coils can be simply be checked using a multimeter. If the machine's coil has two spark plug HT wires then check they are connected internally, by putting multimeter probes into the ends of the thick HT wires, if the resistance is high, around 8 K ohm if so, then all is OK. If there is no connection then get a new coil or suspect the HT wires. If the HT wire is moulded in the coil, check that it is not the HT lead is not damaged, by testing again with a pin pushed into the HT lead closer to the coil. If OK, then cut back the HT lead and simply extend the remains of the HT wire as mentioned earlier. On coils with dual HT wires, there should be no electrical connection between the HT wire and the coils earth bracket. (8K means eight kilo-ohms, 8,000 ohms.)

If the coil has only one thick HT wire, then connect the multimeter across the HT wire and the earth, if there is a high resistance, around 8 K ohm then it is OK.

For both types, connect the multimeter across the small wires, or the small wire and the earth, which is usually the metal bar running through the coil. If these connect internally then it is OK. The resistance for this will be much less than for the HT wire, around 1 ohm.

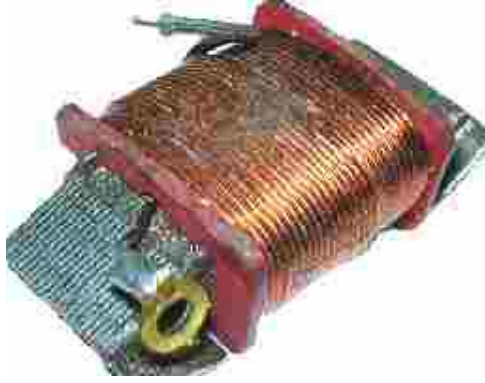
Replacement coils should be chosen according to the system. If buying second hand, most coils are unmarked or marked CDI. Use CDI coils on CDI systems, and use unmarked on ordinary systems. Most coils will do the job, only the mountings will change. Try a selection, you will be pleasantly surprised.

CDI coils usually have more voltage supplied to them, whereas ordinary systems have to make do with 6 or 12 volts.

On high compression electric start engines, where the battery struggles, it may be possible to fit 6volt coils working through a ballast resistor of the same ohm resistance as the coil. This allows the coil to run normally as a 6volt coil during constant use, but when starting, the power to the starter solenoid can also supply a full 12 volts to the coil for a short, stronger burst of energy. This overcomes the heavy voltage drop when the starter motor is used. A ballast resistor is a resistor of the same resistance value in ohms as the coil, so it drops the voltage by half. These are often found as small ceramic devices on some of the older, cheaper machines and also available from most electronic component suppliers. Ask for a 10 watt, 8k ohm resistor.

The picture shows that coils are now very small, some not much bigger than your thumb by using much higher primary voltages from the electronics box, they can now be placed in the spark plug cap, and each coil





triggered from the electronics individually rather than via a distributor.

Brake light switch.

The brake light switch is a simple push or pull to make switch.

These can be rebuilt, but they are cheap replace. Rear brake light switches tend to suffer more than any other item, mainly due to being in the path of road dirt from the rear wheel. Therefore always design with a good waterproof switch, one which had good seal over the connectors and a rubber concertina boot over the operating arm. For dirt bikes, keep the rear brake light switch mounted high and tucked away from rocks and water.

Some touring bikes have a brake or clutch switch wired into the starter button circuit, so the engine can only be started with the clutch or brake lever pulled in. Can be easily circumvented.

Horn.

Two types of wiring, either from the auxiliary fuse to the horn, then to the handlebar switch which shorts the wire to earth. Or a wire from the fuse to the switch, then from the switch to the horn, which is earthed.

The horn can be rebuilt by uncrimping the outer join, but hardly worth the effort. The only problem is corrosion of the contacts inside, and the adjustment of the screw controlling the contacts. Adjust this screw while using the horn.

On machines with minimal electric's, such as mopeds or ultra light dirt bikes, the points inside the horn can be removed and wired direct, making the horn work on the AC current direct from the alternator. The horn sound will vary according to engine revs. Preferably use an original type of AC horn as found on very cheap mopeds as they squawk much louder. Don't knock it, some minimalist bikes do not need DC electricity for lights horn etc. Super light and totally bomb proof. Absolutely wild lateral thinking has been used to supply the power to the brake lights on some designs. When building dirt bikes, less is definitely more.

Dirt bike generators.

All too often a dirt bike has no lights. This is common and may be solved if the basic design can be easily modified.

The few that cannot be easily modified are those with small rotors, such as two stroke motocrossers. If an internal rotor, then it is possible to fit a second external coil for lighting, but these are not always capable of reasonable output for lighting.

Most other dirt bikes have large, external rotors which encompass the internal stators and these can be more easily modified. Again, a second coil is fitted for making the lighting power if none exists.

Whatever design, the second coil will be a symmetrical match of the standard coil, but for lighting, it should be reasonably fat, comparable to other lighting coils from road bikes, and definitely not the size of the original CDI generator coil.

I often try to fit standard lighting coil from scrap bikes as it saves so much hassle. In the worst case, I have to trace around the original and make up a dozen or more steel blanks to build up the iron core on which to wind the lighting coil.

Therefore buying or finding a similar stator coil for modification may be necessary. In

most cases, the iron core of the coil is common to many machines and a second hand or scrap items will suffice.

For desert use, the iron core should be as fat as the outer copper winding will allow, so it may be useful to use two iron cores and glue, bolt or rivet them to make one wider item.

The coil is now wound with the same number of turns, such as a standard bike such as a C90, and if finding suitable lacquered copper wire is difficult, then simply use a C90 for donor wire. I often do.

The copper wire is carefully unwound, so as not to damage the lacquer insulation, although some old nail varnish will touch up any damaged areas. I prefer to lay out the wire in the garden as its unwound. If a fat core, then I may solder an extra length to the basic lacquered copper wire, or to buy some new wire.

The wire is eventually wound onto the motocrosser iron core.

Start by earthing the first end with a soldered connection to the iron core which also connects to the crankcases for a good earth. Usually there is a solder tag for this purpose.

Put a little piece of lacquered (or nail varnished) cardboard or cloth over the iron core to prevent the copper wire from being damaged.

Wind carefully and very neatly, working back and forth along the iron core. Total neatness.

I use a cloth glove for the purpose, as this allows you to apply a little snug neatness to the copper without damaging your hands. Any damaged or missing lacquer can be touched up with nail varnish.

Just before the last set of turns, fit a strip of cloth along the coil so that it is retained by the final winding, and will allow the tail of the wire to be pulled into place. Otherwise, use some cloth to cover the copper wire securely.

The tail end of the winding is led away, sleeved and secured around the stator plate and then soldered to a flexible yellow wire leading to the rectifier/regulator unit.

In most cases, the voltage will be above that needed, and anything about 20 to 35 volts AC depending upon revs is perfectly acceptable. If for any reason, your machine fails to produce such voltages, then either modify the lights to 6 volts, or rewind using appropriately more turns to the copper wire.

The age of the white LED for headlights is still far away, although the latest items can make up a bank of 40 for reasonable lights. Ideally mix wide and narrow angle white LED's to create the spread pattern desired. They can also be mounted high and low, to give a wider range of lighting, especially of riding dirt at night and needing to distinguish the dips and rises ahead, which a single beam is less capable of. (My recumbent push bikes have LED's mounted high, intermediate and also low to the ground for all conditions, including the horrors lurking in inner city street gutters.)

The red LED tail lights and even indicators are a viable and effective option. They work at about 3 volts, so a voltage regulator is needed, or to mount the LED's in banks of four to take the regulated 12 volts. As they need little power, then many LED's will make life very reliable. LED's are cheap - so use them.

I prefer LED's for both tail light, brake light and indicators, even on 450 motocrosser's and they take all the hammering possible, if mounted well. (Silicone sealant and a sense of humour can make a riot of fairground lights across the butt end of any motorcoaster.)

Only the filament lamp headlight is a weak area and this should be rubber mounted. I prefer two smaller headlights, either side and low on the forks, so they take less damage

and don't have to peer over the front mudguard, but this is personal preference and depends upon usage and terrain (forest, swamp, desert, urban etc.)

Modifying motocross or trials machines for road use is common. It can also be done wholesale, by scrapping all the motocross bits if the crankshaft taper fits other rotors. Years ago, I fitted a Honda 90 flywheel and backing plate with spark coil and lighting coil onto a Suzuki PE175 crank flange using bolts as rivets, then timed it correctly using C90 cdi components. Yes, a C90 spark is just as good as any other spark. Make sure the positioning of the pulser is correct before final fitting. This modification started first time and the PE was still working after many years of thrashing. A few welds to the original Suzuki crank mounting taper flange would probably make it even more reliable.

There are many ways to give trials and motocross lights, the simplest is to profile a similar coil to that used for the ignition spark coil, and fit this inside the flywheel. On motocross with minimal flywheel, then this coil is mounted external, similar to the ignition generation coil. In the worst case, use the C90/PE modification as mentioned above, which also gives a little extra flywheel effect for a little more grunt out of the muddier bomb holes.

If all else fails, then simply wind what you can over the existing single coil for the CDI generator, then use LED'd and a 6v 20 watt headlight lamp.

Battery.

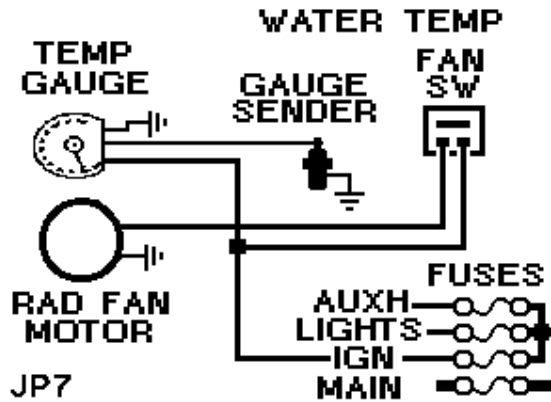
The battery has a limited life span, usually around three years for a cheap one, and up to six years if very lucky for a top quality battery. No repair is possible, but prevention of corrosion of the terminals by cleaning is recommended. Check the liquid level regularly and top up with distilled water if needed, to the mark on the side of the battery. If there is no mark, then use enough water to cover the top of the plates inside by about 5mm. The vent pipe must be kept clear to stop any pressure building up and to stop any corrosive fumes or liquid spoiling the paintwork. Prevention against vibration is recommended to stop damage to the casing and to the lead plates inside.

If the battery casing is transparent, then you can see if the plates are in poor condition. If they are white, then it is badly sulphated and you need to get a new battery. If there is a lot of sediment at the bottom, make sure it is rubber mounted, then start saving for a new battery.

Using a multimeter, check the voltage across the battery when the engine is not running, if it is around 12 volts (or 6 volts) then it should be OK, if it gives 10 volts (or 4 volts for a 6 volt battery) then a cell has failed and the battery needs replacing. Each cell makes two volts.

Gel filled, or sealed batteries have only one option when they fail, recycling at the local dump.

On motocrossers using electric start such as CRF450's, then the battery is a bit of a liability, especially as some have no kick starter. Using NiMh nickel metal hydride units is possible, but can get heavy. Fitting them low down near the starter makes for better handling and shorter cables. An external battery start is possible, with just a token on board battery for emergency use, if you can't bump start the beast when totally knackered. Even a modern Lipo is possible, but expensive. I prefer a bank of NiMh batts, with the attendant need to charge them up monthly if the bike is not used regularly. Most lead acid/gel batts will do and are fairly robust. Whereas NiMh do need



more careful charging, so it is important to fit a voltage sensor and temperature sensor in the battery pack, so the NiMh charge up fast to about 75 percent capacity, then gradually drop down to a trickle charge on long enduros. Ask any flier of model electric planes on just how fast as NiMh can be cooked. I have seen 2200 mAh NiMh's charged /

cooked in 15 minutes ! But they don't last more than a year or so and must be kept cool. For extended road use (and 24 hour endurance races) then get the charging circuit pretty damn close match the battery capacity. It is possible to fit quick replaceable units from electric drills if needed for charging the drill from the bike or to start the bike. Never rely upon an electric tyre pump in the middle of nowhere - carry that push bike pump for puncture repairs.

See also my battery monograph.

Watercooling.

Many machines are water-cooled, but there is little difficulty in connecting the radiator fan motor to the temperature switch positioned in the coolant system. Connect the switch to a multimeter and when placed in boiling water, it should be able to switch 12volts from the ignition or auxiliary circuit to power the cooling fan. Or to warn you to carefully clean out the crud building up in the radiator.

The temperature gauge usually has three connections, an earth, 12volts and a third wire to the temperature sensor, which is usually mounted on the cylinder head. To check, place 12volts across the gauge and the third wire to the sensor, not forgetting to add a temporary earth wire to the sensor body. When heated slowly by placing in a cup of hot water, the gauge should move accordingly.

Fuel pump.

The basic external type is used for carburettors. A higher pressure version for fuel injection systems. External pumps for carburettor systems usually work with a large solenoid to pump a rubber diaphragm with simple inlet and exit flaps. The solenoid is operated via a set of points which occasionally corrode or weld. They are often rebuildable, so check for genuine spare parts, rather than replace the whole device. If the fuel pump fails, it may be possible to lift a fuel tank and use gravity to supply the carburettor until out of danger or a replacement is found. If far from nowhere, then open up the fuel pump, connect two wires across the damaged points, one to feed power from the battery, the other with a bared end and taped to the handlebars, allowing the rider to switch the pump manually with the bare end of the wire to earth every so often. The pump usually only needs a short half second pulse, every minute or so. Fuel pumps as used inside the fuel tanks of racing machines are dangerous to repair. The fuel often flows through the motor itself, and undue friction may cause problems. Replace or exchange with genuine components.

When using car fuel pumps, such as on trikes, they are available in a choice of two pressures. One about three psi, the other about six psi. The low pressure type is for a pump mounted near the carb. The high pressure pump is used when mounted near the rear fuel tank of a front engined car.

Connect the fuel pump on the ignition circuit so it won't pump when parked. Use a separate fuse, because pump contacts occasionally weld themselves together. Spare

contacts are normally available for decent electric fuel pumps, although a spare fuel pump from a scrap yard is much cheaper, especially if fitted close to the original, for a quick swap. Done properly, the rider should be able to swap the pipes and electrical connector over with minimal hassle.

As fuel pumps are not always close to the engine, especially on some trikes, use steel fuel lines which run through the chassis area, with flexible ends at fuel tank and at the engine. The engine flexible pipe should be quite long to prevent excessive bending if an engine moves about on its rubber mounts.

Always test spare components in situ with a few hours of riding, so they work well, then clean, use maintenance spray and seal against corrosion. On trikes this can be very important, such as if a car distributor or other item needs alignment, a few dabs of paint will often help correct alignment during replacement, ensuring the spark plug leads go to the correct spark plug.

Fuel injection.

Always fit and use as the manufacturer intended. Use standard chips in any engine management computer until everything else is fettled. A fuel filter must always be used, and usually the type for a pressurised system. As fuel injection is expensive, use a new fuel filter, then strip the old filter to assess the state of the fuel tank.

As the fuel lines forward of the fuel pump are at high pressure, make sure all pipes are protected and rubber mounted to prevent rubbing and wearing on the frame. Always keep away from exhausts. Fuel injection imposes a computer or similar, so keep this dry and mounted in soft foam, usually under the rear shell, or make a safe box for it with the other electrics such as relays and fuses. Compact computers can get hot, so allow cooling air flow if it shows any signs of getting warm. Check after a few minutes running and after half an hours running.

Again ensure all wiring is well protected with rust preventing maintenance spray.

Where covers are not used, the fuel injectors are open to the weather, protect the injectors with the genuine rubber boots and fully spray to prevent corrosion of the wiring and connections.

As most fuel injection systems use pressure or volume sensors in the air inlet plumbing, air and engine temp sensors, and a host of other sensors, always start by using the wiring and plumbing exactly as the manufacturer intended. Nothing removed, nothing replaced and nothing added. You WILL need the manufacturers circuit diagram. You will need to keep the airflow sensor and the whole air filter system. The parts may be able to be repositioned, but must retain their original purpose and general orientations. Most wiring can be replaced, but go carefully and copy all colours. Wiring to injectors should be single lengths, as unnecessary connections can cause resistance problems. If in doubt, always overspecify the wire. Heat resistant or silicone wires can be considered if well supported. If in doubt, or problems occur, all pulsed signal wires to the electronics unit such as timing pickup should be shielded. Constant voltage signals such as air flow or air temperature can be simply wired. Make sure of good, and preferably the minimum amount of connections, especially on temperature sensors and sensors based on rotating potentiometers, where resistance problems may cause 'age creep' of the various settings.

Never play around with a fuel injection or other sender, such as the pot on the side of the carb butterfly. If it must be adjusted, scribe a fine aligning mark first.

Winding your own components.

As many Japanese and Italian manufacturers use similar national suppliers of electrical components, there is a surprising amount of common compatibility. This allows a lot of 'mix and matching'. Physical comparison often does well for small bike components, and occasionally a few larger bikes too.

Likewise car components, such as a recent Ferrari ignition sensor which failed and was easily rewound for a tenth the cost.

Simple alternator coils and other wound components can be rewound by hand. The classic case is after sliding down the road, where the alternator internals suffer their own version of gravel rash. If it is to be replaced, then buy some lacquered copper wire of the same size and try rewinding first, especially if your leg is in plaster and you have plenty of time.

Start by noting the positions and colours of the wires and noting down details as the wire is unwound, especially noting the number of turns.

Carefully unwind the old copper wire and lay out carefully as it unwinds. Measure the wire diameter without the lacquer and buy similar lacquered wire, or re-lacquer if partially rebuilding using old components. It is sometimes easier just to replace the winding with a second hand component.

Solder any start terminal which is often an earth tag at one end and an insulated fly lead at the other. Wind carefully in the same direction and manner as the original. Use soft cloth gloves to allow smooth, undamaging pressure on the lacquered wire while winding. When close to the end windings, it may be necessary to wrap in a fold of cloth to retain the final windings in position. This cloth should then be lacquered with simple lacquer such as nail varnish, epoxy resin or similar.

Overall restraints is by wrapping with cloth over the whole of the winding, then lacquering or using epoxy resin.

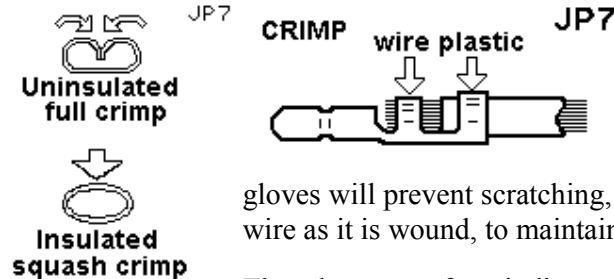
Some small bike coils have intermediate 'taps' which are extra wires soldered part way along the winding. These should be copied from the original, and soldered where needed during the winding, with any insulation if fitted. They usually include lacquered cloth insulation tubes which should be reused or replaced with wraps of cotton and then lacquered to prevent electrical contact between the wire in the winding.

Some windings are simple, such as the lighting coil on a small bike. Other windings can be more complex, by the way they are constructed on many steel, radially aligned pillars, or the number of intermediate 'taps' or simply the number of turns. Take careful note when unwinding, especially the number of turns and also the direction that the wire is wound onto the iron core.

Where a CDI ignition generator coil is to be rewound, it is the number of turns which is important, with the number of turns accurate to about five percent or less.

When winding such coils with many turns, it is better to buy a second hand item from a scrap dealer. If intending to try, make up some form of winding mechanism, such as a minimalist wooden lathe arrangement using a rechargeable drill, set at a sensible speed, so the wire can be wound continuously and evenly. Always use a bright marker on one side, to make the counting as easy as possible. A wooden dowel, with a small wooden box arrangement to hold one end of the coil onto a rechargeable drill may suffice. If doing this regularly, then fit a lug which switches a microswitch on every turn, then wire this to the + connections of a cheap calculator. Then type in +1 and the counting will be very easy.

If a winder is not possible, then position the coil so your arm does as little work as possible. The supply bobbin of wire should be allowed to unravel easily and cotton



gloves will prevent scratching, while allowing the fingers to lightly tension the wire as it is wound, to maintain a good, neat winding.

The advantage of rewinding such generator coils oneself is that liberties can be taken with the design.

A recent CDI custom special of the authors needed to retain the '12volt' cdi system, but preferred a 6v lighting system to keep weight to an absolute minimum, by using small NiMh batteries in the frame tube to power just the indicators and horn. The lighting battery generator coil was carefully unwound and the wire folded half way, with an earth tag fitted half way along the wire. This was then rewound as a pair of wires and used in 6volt mode. The reason why this was possible is that only half the number of turns was available on each wire, causing only half the voltage. But as the wire was doubled, the output of the 6volt wires was therefore double, allowing the same wattage lights etc, but at 6 volts rather than 12 volts.

Likewise a 6 volt lighting coil can be rewound to supply 12volts simply by halving the cross section of the wire and doubling the number of turns.

Refitting old multi-pin connectors.

If a connector is badly damaged or corroded then the only solution is to replace the connectors, this is also partially covered elsewhere in this monograph.

It may be found that the ordinary wires are badly corroded and when the insulation is stripped back, the copper wire is black. In this case replace the wire, or strip back further until the wire is clean, after which it is possible to crimp fit new connectors. If attempting to solder to poor wires, then use a good flux to remove the corrosion. After soldering make sure that all traces of the flux are removed otherwise it will corrode the wire. To simply prevent corrosion recurring, use new wire wherever possible.

To remove the connectors from the plastic, use a small flat blade such as a watchmakers screwdriver to bend back the retaining tab on the connector, and remove by pushing the connector or pulling the wire. A straightened paperclip with one end flattened will do nicely.

To remove the connector from the wire for re-use with new wire, the outer crimp can be gently removed and the copper core crimp must be cut and filed to allow the new wire to be soldered in position. Small wire cutters can carefully ease back the tags to allow the connector to be re-used.

Crimping.

Crimping a decent terminal to the wire is important. There is nothing worse than a poor connection. One crimp makes the electrical contact and the other makes the plastic covering secure.

Strip a wire to expose 5mm of bare wire. Place the wire so that the bare wire is crimped by the inner lugs first, then the plastic insulation crimped by the end lugs. Once done, try pulling the connector off the wire. If done properly it should need pliers to remove. Note the type of crimper used will depend upon the type of connector.

If the connector is not the correct size, it is often possible to double up the inner wire to make an adequate crimp fit.

Wherever possible use uninsulated connectors, similar to those used by the Japanese, and use their separate plastic sleeves or multipin holder. Other connectors - no comment, as to criticise is impolite.

Fitting your own Advance and retard units.

Do NOT Do This:

If you have a four stroke engine and manage to wind a higher voltage CDI charging coil in the flywheel generator and can get a spark from it using the other components, (perhaps sticking a old fridge magnet to the flywheel to get the pulser to work) while cranking over and checking for a spark, then you may need an advance and retard unit. If wanting to make your own advance and retard unit, perhaps for an older bike, extend the camshaft, by drilling or welding a shaft or stud into the end of the camshaft, and extending it out through an oil seal.

Most camshafts will need drilling centrally, so remove any end plug, and pack some cloth around the camshaft oil area. Use a drill and start the bike engine, then drill a perfectly concentric hole in the end of the camshaft. Stop the engine, clean up the swarf, the tap a thread into the camshaft.

The end of the camshaft should make a perfect abutment to the advance and retard shaft, held by a bolt into the camshaft. If the camshaft and A/R unit do not fit too well, then it may be suitable to extend the camshaft by fitting a bolt in the thread, such that the bolt can support the A/R unit. Either method must ensure the A/R unit will run perfectly concentric with the camshaft.

Rotate the engine on the electric start and make sure the new shaft is perfectly concentric, or modify so it runs true.

Place a standard oil seal around the shaft and build up the casing to take the seal with 'epoxy metal in a tube'. This is available from most car and DIY shops.

With the seal and extended shaft, fit the CDI pulser and advance unit from an eighties bike such as an XL125. Then build up the camshaft area with 'epoxy metal in a tube' to make a simple cover and to hold the pulser in position beside the rotating advance retard unit. This shaft will probably need a slot or hole to align the advance retard unit and a pair of retaining screws.

Rotate the engine to the static firing mark, F, then align the advance unit and the pulser so they line up. There is often manufacturers marks for this.

If a four cylinder, then you'll be adding a second pulser coil 180 degrees apart, or if a V4, then at 90 degrees or whatever is needed for your machine.

Check the spark advances as required, or be prepared to bend the centrifugal weight end stops to get perfect advance position, then adjust the springs to get the best advance curve.

Tools.

The usual tools are pliers, wire snips, strippers, crimpers, heatshrink. Bulb and croc clips, screwdrivers. Soldering iron, either mains, 12v or gas. If working away from a workshop or electricity, then one of the butane gas soldering irons is ideal for rewiring bikes and trikes.

A multimeter is not essential, but even a cheap one can be used to check the charging voltage of the regulator when the engine is running. Bikes do not need expensive multi meters, so buy a basic multimeter which is able to measure up to about 40 volts AC and DC. Most will measure to about 250 volts so you can check household electrics as well. The meter should also measure resistance up to around 10 Kilo Ohms. If possible, choose one which can also measure up to 10 amps, although this is not an absolute necessity. A multimeter is simple to use.

To check voltage, select the voltage range and connect the black lead to the earth and

the red lead to the part you wish to check for voltage, such as the voltage across the battery, then read off the voltage on the scale. On the resistance setting, set to read ohms, the meter can check the continuity of wires and switches and the resistance of ignition coils, alternator windings and rectifier. On the 10 amp range, each components can be checked for the current it needs, so the fuse rating will be sensible. The bulb on two croc clips is less sophisticated, but will still tell you if electricity is flowing or not.

If rebuilding switches, then a pair of cheap, fine forceps or strong tweezers are priceless.

Also needed is some cleaner such as methylated spirit, silicone grease, fine grade wet and dry abrasive paper and a few clean rags.

SECTION 4.

Bits and pieces.

Fitting an after market electronic ignition.

When choosing to fit an after market electronic ignition then check with others who have used the same type for reliability before buying. Read the instructions first, check it is for your model and does not need any extras.

If you are going long distances within months of fitting one, take the old contact breaker parts with you, as like all electronic equipment, failure is usually early on or not for many years.

Fitting an after market anti-theft device.

Choosing an after market alarm is fairly easy, but the following must be kept in mind. Will it fit your bike, how big is it, and where will it fit?, does it protect the bike the way you want? is it just an anti tamper device, which sets off an alarm when moved. Does it reset after 30 seconds or so, as no one wants to get up in the middle of the night to re-set an alarm. Is it a complete set-up with cable for securing to a lamp post. Is it self protecting?, and does it have loads of other useful (and not so useful items) which can push up the cost. The actual fitting can only be assessed when buying, and the installation instructions must be well read, especially if you are the one who will fit it. Will the machine be likely to be stolen by joy-riders or for spares. For joy-riders, it necessary to disable the machine. For parts collectors, simple datatagging or micro-dots may be more effective in some circumstances.

Simple anti theft ideas.

The simplest is a hidden kill switch connected between the kill switch and the coils. Another option is a mercury switch which can set off the horn when the bike is lifted upright off it's sidestand. A cheap mercury switch is position sensitive and need to be fitted in an adjustable clip to set them at just the right angle, the mercury switch is used in a separate circuit using the battery, a hidden switch (or the parking light circuit if available on the ignition switch) and a horn. Even if the battery runs flat with a simple design. at least you will retain your bike.

The best way to protect side panels is to physically constrain them by a method only accessible from under the seat, such as an R clip through a hole drilled in the side panel mounting lug, with an extension rod if needed.

When protecting side panels with electrical connections to the alarm, most micro switches have on and off positions, allowing them to work either way.



Why a bike can have 4 plugs but only 2 coils.

Although taken for granted, this is an elegant solution to using four coils when two will do. The use of two coils is dependant upon the fact that the typical four cylinder bike has pistons 1&4 and pistons 2&3 at the same position at the same time, this is done for good balance of the engine, and smooth power output. It allows a single coil to spark two plugs at the same time, one when the spark is needed at just before TDC (top dead centre) on the compression stroke, and the other when the spark does no harm, on the exhaust stroke. The coil has two HT leads, both connected together internally via many thousands of turns of fine wire to create the high voltage, to form a circuit with the spark plugs, and the cylinder head as an earth, so that the only gaps are the plug gaps. This is the only 'circuit' on the bike designed with gaps in it. If you do not know which HT leads go where, then try one coil's leads to cylinders 1&4 and the other to 2&3, if this does not work then swap either the HT leads, or if they are already cut to set lengths, then swap the small wire connections to the coils from the points (or electronic ignition).

In an emergency, two separate coils can be used, triggered through a single contact breaker.

Customising.

This is an open book. Absolute neatness is paramount. Preferably the wiring is never seen, but when the inevitable wire must be seen, it should be impeccably positioned and have style. Never allow connectors or components to be seen unless absolutely necessary.

If many extras are integrated in the machine such as auxiliary lights, horns, and lots of extras, then always build a separate wiring loom, so the main loom is not compromised. Running wires through frames, handlebars and under mudguards is mentioned earlier. When things go wrong, a well designed wiring loom will allow the extras to be disconnected or even removed to leave just the basic working loom to get the machine home.

Digital speedo etc.

The type fitted to motorcycles are usually wired as fitted to standard machines, but can sometimes be modified for other machines. Adjustment for differing wheel sizes is usually dependant upon adjusting or changing parts on the printed circuit.

I often use digital speedos from common motorcycles for my own use and even use them as part of my head up displays, but that's another story.

The LED design shown opposite is for most motorcycles and has the central digital speed, a curved tachometer bargraph, fuel bar graph and the usual modes of time, elapsed time, average speed etc., as found on most cycle computers. It is mounted in an outer plastic unit with ancillary orange indicator lights, oil warning, neutral, high beam and other lights.

This design uses simple inputs:

It runs from 12 volts for use with the ignition on, with a secondary back up supply when the ignition is off. (This example happily runs off 6 volts, so presumably uses 5 volt electronics with an internal voltage limiter.)

The speedo uses the simple reed switch and magnet on the front wheel. It can also be used on the front sprocket sensor of later machines, but the gearing will have to be re -

calculated.

The tachometer uses a simple pulse wire to the coil inlet or wrapped around the HT lead.

The fuel gauge uses the standard (Japanese) style fuel level input.

These digital designs allow very simple integration of the design to most machines, as the speedometer and tachometer are adjustable for wheel diameter and maximum engine revs.

If a basic digital display is needed, then the easiest is a cycle computer.

The cheap cycle computers are suitable for motorcycles, but usually only allow 99 MPH. Motorcycle versions are also available with three digits for speeds over 99 mph.

These computers allow the effective wheel circumference to be inputted accurately.

Place the tyre valve at the bottom, then roll the bike wheel one full turn and measure the actual distance along the ground for true actual road speeds.

The larger digital units from motorcycles and cars are usually operated from a reed switch from the speedometer cable to the odometer, or via a pulser from the engine sprocket.

If the reed switch type is used, then simply re-routing this onto the wheel, and applying a magnet will allow a simple, approximate readout to be possible.

If using the gearbox sprocket or the speedometer cable was geared 1:3 then 3 magnets may suffice. This can then be refined in the circuitry. The other connections are usually 12volts and earth, plus a few other wires for switching between mph/kph etc.

Digital tachometers should be used as the manufacturer intended, as over-revving can be dangerous. If making your own using LED bargraph display drivers, then always shave the red LEDs at the over rev section to be flashing LEDs, as these give superb racing warning, not dissimilar to F1 cars.

Digital clocks can be bought almost anywhere, and a back light can be employed by deconstructing the case and using simple LEDs shining sideways into the side of the LCD display. If a 12 volt micro light, then this can be connected to the speedometer lights for night use. Ask in model shops for 5 volt or 12 volt 'grain of wheat' lamps.

Most LED or LCD power supplies can be catered for by a small Nicad battery, charged via a small 6v voltage regulator and resistor from the main bike battery. Only applicable if the unit contains volatile information which would otherwise be lost when power is switched off, such as wheel diameters or an odometer.

Head-up displays, as used on fighter aircraft, which project analogue and digital information into the line of sight in the windscreen are not covered here, but are possible on some motorcycles such as the JP7.

Off road bikes.

See also Dirt bike Generators, above.

Off road bikes have many problems, of which vibration, damage from drops, the perils of water, and poorly positioned trees will cause problems for the wiring.

Vibration can damage the bulbs, delicate electronics and batteries, so all must be well insulated from the vibration either by using a rubber mountings, or by packing delicate items in foam rubber.

The problem of water can be overcome by the liberal use of silicone sealant, which can be applied to clean surfaces around any suspect entry points to the engine and airbox.

Use clear sealant, as it shows up corrosion which would otherwise be unseen. If the connector is to be disconnected regularly, then use a rust preventive waxy coating before the silicone covering.

Route all wires away from splashes and damage from rocks and earth thrown up by the wheels, and clear of the exhaust.

If using an ignition switch, then this may be fitted in the air filter box with other electrical items if there is room, as this gives easy access and good waterproofing, while keeping many of the wires together in one place while still allowing some cooling airflow for the regulator. Best to position the ignition switch to point forwards, out of the way, or recessed with a bent or flat, round and compact head to the key, allowing the leg to slide past without switching off the ignition.

The kill switch should be the best quality you can find, as this is always a weak point in the circuit, and make sure the wire is well out of harms way. Always have the kill switch on the handlebars, easily reached from either side when pinned down under the bike.

Tail light wires must be well out of the way of rocks from the rear wheel, and from melting from the exhaust, usually routed above the rear mudguard. On enduros, try to fit the tail light on flexible rubber so that if it is hit in a fall, it has chance to flex rather than break. Where regulations permit, use a bank of many LED's which are more resistant to vibration and damage. See also tail lights as mentioned earlier, regarding a one-piece three core cable to the headlight.

If the headlight sticks out then it is more likely to be damaged by trees or falls, so mount a small headlight in close as far as possible to the forks, so the handlebars and forks to take most knocks. A wire frame protection is useful, but carbon and aramid are much lighter and slightly flexible if designed well.

For quick-disconnect lighting etc, then there is the problem of the connectors getting dirt in them when separated. Try to position the connectors out of the way, or leave them with extra length so that they can be tucked away securely out of harms way, or at least dangling downwards, minimising water penetration. Using a spare dummy male connector which is sealed and secured to the frame will reduce many problems of water ingress and flexing around. Always make the connectors safe, as mentioned in section one, ensuring that when disconnected, there is no chance of the wires or connectors shorting out to the frame.

A lot of electronics can be safely positioned in the airbox.

Always keep the ignition circuit separate from the other circuits such as lights, and where possible, fit backup coils, electronics etc.

See also horns for alternatives to complex wiring.

Storing a bike.

Run the engine until it gets warm, preferably after a long run, to clear out the cobwebs.

A cloth stuffed in the ends of the exhausts and airbox entry will reduce rusting. If fancy airducting, simply cover the airfilter element with a poly bag and replace.

Place the bike on the centre stand, or block the wheels off the ground. If for very long-term storage, then boot polish the rubber tyres so they do not succumb to corrosion.

Likewise any other rubber component. Release all drum brakes and turn the wheels occasionally. If storing outside, then lightly grease or lacquer any steel wheel rims and all wire spokes.

Always disconnect the battery, either by removing the fuse, or preferably completely removing the battery. This way, there is much less chance of the bike corroding and the battery can be topped up with an occasional charge to reduce deterioration.

Spray all cables, connectors and switches. Drain the carburettor and leave the drain screw loose should the fuel tap leak, filling up the float bowls again.

Not much else can go wrong with the wiring, although long term corrosion usually attacks the copper cores inside the wires, usually via rain, and rust also attacks the switches and lamp holders. Keeping dry is the best remedy. Either spray with lacquer such as hair lacquer over all connectors, or with silicone maintenance spray, preferably after a couple of really hot, dry days. Lacquer also protects other bike components too. Choose the type which is slightly flexible. If the battery is ignored for more than a year, it is probably worth replacing, unless discharged and recharged every few months. The spark plug can be removed and a little two stroke oil poured in the cylinders, then the engine rotated a few turns and the plugs lightly replaced.

When returning to use after a few years, add a note to remove the plugs, poly bags, rags etc. Then turn the engine over with a little petrol in the barrels. Then clean and replace the spark plugs. Also recharge and replace the battery. Then re-tighten the carburettor drain screws. If all's well, there should be no problems.

Trikes.

For a comprehensive guide to designing and building your own trike, see my website.

The choice of engines is vast. From mopeds to gas turbines.

Most bikes based wiring ideas are already covered.

All car engines use alternators which are simple, self contained items.

Sparks often triggered by distributors on older cars.

Always make sure that a modern engine comes complete with its ignition, fuel injection / engine management system. As long as the engine runs, leave as is, the rest is simple.

If in doubt, always get the complete vehicle, or at least the complete engine bay up to the dash board, and the whole of the wiring. Some important electronics may be in the boot (trunk). E.g. TR6 and V12 jags. See also companion trike monograph by the author, available via my website.

Distributors.

Distributors usually include the mechanical advance retard unit similar to that used on bikes. This includes the points or electronic pickup pulser coil, again similar to bikes. (They did not invent very different electrical systems for bikes or cars.)

Distributors have many advantages, allowing simple adjustment by turning the whole body of the unit and needing only one set of points or electronic ignition unit, and one coil.

If the firing order for the sparks is not known, remove the rocker covers to reveal the valve rockers. On four cylinder machines, pistons 1&4 move up and down together, and 2&3 are 180 degrees offset from 1&4. Turn the engine until valves on cylinder four are just both opening, whereupon cylinder one is at the firing position. Remove the distributor cap to see which HT lead the rocker arm is facing. Connect appropriately. the opposite HT lead on the distributor then goes to cylinder four. Then do likewise for cylinders two and three. Similar process for other engines. Mark the HT leads accordingly, using dabs of yellow paint.

The points gap can be adjusted, then the distributor rotated slightly to set the ignition timing using a bulb and croc clips across the points with the engine positioned at the static timing mark.

Vacuum advance on the distributors is connected to the inlet manifold and this adjusts the ignition timing according to the pressure in the inlet manifold. It is common to disconnect the pipe when setting up the ignition timing by strobe at tickover.

The dual tail, brake and indicators, operated from stalks on the steering in a car, are just simple variations on the basic themes but unsuitable for wet weather use. The brake and tail lights simply being extensions of one tail light and brake light. Indicators remain identical systems. Side indicator repeaters can be added for those who wish, and recommended on long trikes.

Side lights are needed for trikes (naturally), as the single front light may confuse others as to the vehicles width. Side lights to be positioned on the sides, and easily visible from front. The lights to be white, 5W lamps pointing forward. If only one tail light is used, then rear red facing lights are also needed, although these can be the rear faces of the front side lights using a single lamp each side of the trike. If two wide tail lights are used, the rear side lights are not needed.

When wiring the rear of a trike, it is often simpler to make a single sided loom which goes to one tail light assembly, then with repeater wires to the other side. Ensure the wiring is securely mounted away from fuel and exhaust.

Car alternators are far simpler than motorcycle alternators, as they are self contained, needing only an earth wire, a main 12volt wire. They usually offer a connection for a warning light, if needed, which will remain lit while running correctly.

Car alternators supply fully rectified and regulated 13.8 volts ready for use. An alternator can be positioned almost anywhere a V belt will fit. Make sure it rotates the same way as originally fitted, or simply turn it around, or use a different alternator.

Reversing lights are often actuated by a switch already supplied on the gearbox. If not, use a simple push to make switch mounted on the gearchange which will only work when in reverse gear. Positioning should include slotted mounting holes and a basic adjustable switch such as some of the various motorcycle brake light switches, which have the advantage of being waterproof. Reversing light switch is basic wiring from the auxiliary fuse to the switch to the reversing light, plus an earth.

The handbrake warning light if needed is a simple switch often connected to the handbrake lever via a basic bracket, connecting a live warning light to earth.

For initial testing of the engine, simply use the standard donor vehicle wiring loom, then carefully remove or blank off what is not needed.

The handlebar switches for bikes will not always manage the power of trike head, tail and side lights, so a relay is often needed. Indicators are usually OK.

Main beam, indicators and horn switches can be made to fit by opening up the car stalks, and deciding which wires are which, then paring them back extending and connecting to bike switches as they often work via relays.

Fuel injection usually imposes a computer or similar, so keep this dry and mounted in soft foam, usually under the rear shell, or make a safe box for it with the other electrics. Keep fuel injection systems on their own cosseted little circuit, and well protected with the correct fuse rating.

Again ensure all wiring is protected well and further protected with rust preventing maintenance spray on the connectors.

Where bonnets (hoods) are not used, the fuel injectors and associated components are open to the weather, so fully spray to prevent corrosion of the wiring and connections, then protect the injectors with the genuine rubber boots with a little clear silicone sealant or lacquer.

As most fuel injection systems use pressure or volume sensors in the air inlet plumbing, air and engine temp sensors, and a host of other sensors, always start by using the

wiring and plumbing exactly as the manufacturer intended. Nothing removed, nothing replaced and nothing added. You will need to keep the airflow sensor and the whole air filter system etc, etc. These parts may be able to be repositioned later, but must retain their original purpose and general orientations.

Where a fuel pump is used, it should be wired in the ignition circuit. As the fuel pump is important during testing, be able to wire direct in an emergency to get home. Also include spare wiring such as to include an emergency direct connection to the ignition coil.

On very sophisticated or expensive engines, the main ignition switch circuit should split into at least three fused circuits, (1) the coil and CDI unit for the sparks, (2) the fuel injection, and (3) the fuel pump. Each should be protected by its own fuse. When you switch off the ignition, all three must switch off.

If required, separate switches can be used to supply power from the main ignition switch to each circuit, aircraft style. E.g. sparks on/off, fuel injection on/off, fuel pump on/off. (Mainly for show use only or if building with aircraft engines.)

If using this style, always have the switches in a sequenced row, so you can easily switch each in turn, - fuel pump first, to build up pressure, then fuel injection computer to begin reading the temp sensors etc and settle down, then the sparks, and finally the starter button. Flick, flick, flick, press.

For styling purposes, starter switches can also be operated by an identical looking switch but with a momentary action.

A small light above each switch can be used to check if its on line, or to tell if the fuse has blown and that the circuit is out. Safety flip covers, or protection bars between each switch are also useful. Do not put a safety flip cover on the spark/ignition switch if there is no dedicated kill switch or if the ignition key is hard to reach. Always have a safety cover over the starter button unless an electrical lock out circuit is employed.

If employing an exotic engine such as an aircraft engine or perhaps a helicopter gas turbine, then be prepared to work with 24volt systems and always get the circuit diagrams, manuals and associated dials and gauges etc. Also engine logs and any ground support equipment which may be needed.

Where the tail lights run under a trike body shell, use tubing or locating tabs to keep the wire from rubbing against frame, tyres etc.

Radiator cooling fans are often operated independently via a temp sensor switch which may switch the fan directly or via a relay.

Electronically operated transmission devices should be operated as per the original manufacturers fitment.

If in doubt, or during the testing process, keep the wiring very simple and use separate ignition circuits. Protect each circuit with its own fuse. Many separate circuits are easier to build and repair than one big circuit.

Typical bodes and why they fail.

The biggest bodge on many custom bikes and trikes is the wiring.

This seems traditional, but it is hoped this monograph may help to undermine this tradition. Do the job well and take some pride in the work, as a decent wiring loom will enhance any bike or custom, giving pride - and peace of mind.

The infamous electrical tape covering two bare ends of wire twisted together will get you out of a fix. But it will soon corrode when water gets in and be easily separated when pulled.

The poor routing in wrong places such as the alternator wires resting on the exhaust after the electrical tape has been warmed by the exhaust and given way. So do not skimp on buying the small, insignificant metal tabs that hold the wiring to the engine and frame. When building a frame, always cut small strips of steel which can be welded to the frame to retain the wiring loom. This is especially important where electrical tape wound around a frame to hold the loom will spoil the look of the machine. Then slide a little plastic sleeve over the metal tag after spraying and artwork, so it does not cut through the loom.

A poorly mounted tail light wire rubbing against the rear wheel, when hidden inside the rear mudguard is obvious but still very common, so before routing a wire, think it through.

Steer clear of using the 'chocolate box' multi screw connector.

Always use colour coded wires which are so easy to reconnect correctly.

A big 'bodge', is not bothering to make a wiring diagram at the time. The lack of planning of a rewire can cause more problems than you can imagine - especially after a few years when something goes wrong.

All bodes are just doing the job just enough to work. This often ends in failure when you least need it. So think things through, understand the problem and it's solution, then fix the problem as well as is practically possible.

Other hassles.

The main areas of concern may not be the actual wiring, but the hassles of getting to the wires.

The sheared bolt, tight screw, mismatched switches and other grief. This section can only be a guide to preventing some of the major problems which are often encountered when rewiring a bike.

The main problem is again, corrosion, causing screws to seize, connectors to corrode or even break, and generally set traps for the unwary. Everyone has their own way of working, but if some precautions are taken then the way will be easier.

Before rewiring, check what way the various parts are internally wired, so use penetrating oil for a few days on difficult screws before removing and getting the correct screwdrivers to fit.

The worst set of problems is when you get access to the bits and pieces inside, finding the wires from the switches or alternator are mangled, broken, badly corroded and must be replaced. If this is so, you will find in almost all cases that the wires can be followed back to a soldered join. By repairing one wire at a time, then many switches can be recycled fully, or retained for parts.

Fixing an old loom.

The best opportunity for an easier life, is before the rewire. Take the opportunity to check the present wiring for faults, finding out why the problems happened.

Many builders are daunted and often shy away from the common mess of multi bodged wiring on neglected machines. From this mess can be teased a fair number of clues including the manufacturer of the component, often by wire colours, or reading the 'shape' or the lettering on the part. Take it to a competent bike shop and they will often tell you its origin and replacement price. Check both original and 'pattern' prices. Where

a component is physically damaged, it may still work electrically.

The author has worked in many bike shops, and recommends a competent shop, one which works with many makes of bikes, and in all conditions. An up-market motorcycle dealers shop is of little use, whereas a pragmatic shop with an honest and genuine turnover of all makes of bikes has a knowledge base far in excess of most others.

Fixing an old loom can be fraught with problems of corrosion and wear. The loom may also have been repaired with wires of indiscriminate quality or colour. Switches and wires may have been modified or circumvented, requiring a complete reassessment of the way the loom is applied to the bike.

Corrosion can find its way very deep into the plastic insulation of a wire, making it useless, requiring full replacement. If in any doubt about any wire, replace it.

Sometimes its last act can be to wrap the inner wires to a new length of wire, to pull the new into place.

To check an old wiring loom, inspect it on the bike, then if in a poor condition, remove it and remove the outer wrap. Work through each wire with a meter, flexing each and every join and connector for failure. Also flex the wires, especially in the steering head area for wear and in the tail light areas for corrosion. Always start by looking for physical damage, as this is the most common. Most electrical faults are not electrical, but physical.

Wiring looms, like all bike parts are subject to wear and damage. The most common faults include wear from corrosion causing the dreaded black copper wire, the awful corroded contact, or the worn insulation rubbing on the frame. Poorly built wiring, constant moving around the steering head is no fun either. The whole wiring loom if vandalised and cut at the steering head area is a cause for grief, but can be patched together with time and patience, plus solder and heat shrink.

The worst problems of old looms include intermittent faults from corrosion, and sudden stopping or blowing of fuses from short circuits due to wear of the insulation. Tracing such faults can be very difficult. Not surprisingly, the best way of finding them is to thoroughly check each circuit one at a time. Once the problem circuit is found, deciding just where the problem lies is done by trying to get the fault to appear again by pulling, twisting or similar of the wiring. Sometimes this will not work, so you will have to take each wire, one at a time, especially where one wire is connected to two or more others by a join inside the loom.

When the loom looks good, it may still be bad. Some flexing connectors can work the connectors loose, which then make poor connections which will get warm and eventually melt or corrode the connection. Each and every male and female connector can be easily and quickly tested with a new matching connector. This is to ensure they make a good, firm physical contact which will then make a good electrical contact, with no resistance, thus no heat and therefore no damage.

When reasonably competent, it is far easier to make a new loom than to fully repair a badly damaged or old loom.

Equipment Differences.

Although there is a vast array of electrical components for motorcycles, they almost always do the same job. A rectifier for a common machine will often be recycled for a similar machine. Likewise, pattern or generic components can replace expensive original equipment manufacture (OEM) items.

Never be afraid to fit an equivalent component from another machine, if it does the job. Ignition coils are common for most machines. Only alternators needing a rectifier/regulator unit with a field coil control will need original replacements. Although the basic ideas used to wire a bike are the same for all bikes, some makes use different ways of doing the same job. A little time will allow the builder or modifier to see how it works and how it can be repaired, modified or replaced by an equivalent device.

Many of the larger Suzuki's (1980's) used a double pole, single throw light switch. One side works the lights on / off, the other part of the switch connects one of the three white wires from the alternator to the regulator, and must be connected to the alternator/rectifier wires according to the manual, to keep the rather basic charging levels correct. It simply disconnects one of the three alternator AC wires when the lights are not used, to help balance the charging system.

With earlier British machines the alternator output may be kept at 13.8 volts by a device called a zenner diode. This is a small brass bolt device with a central blade connector which connects to the battery side of the rectifier and dissipates any excess electricity over 13.8 volts. If fitting two, to handle larger generators, they must be matched pairs. Alternatively, consider using a modern rectifier/regulator unit to control the output of the alternator.

Very early bikes use dynamos which use a special regulator box to keep the voltage correct and to prevent any current from the battery going back through the dynamo. To check the regulator, watch the small contacts as the engine speed is increased, one of the contacts will move rapidly to keep the voltage constant, and this is the one to adjust. Measure the voltage when the engine is running at various speeds with the lights off and on, and adjust the metal tabs above and below the contacts, to get the voltage right. A manual is highly recommended for the machine as they can differ between makes. One of the other contacts is to ensure the dynamo is disconnected when the engine is not running. This set-up is often similar on some early Japanese four cylinder machines and for dynastarts as used on early electric start Yam 200cc two stroke trail and road bikes.

When confused by far too many electrical gizmos such as self cancelling indicator units, then circumvent the problems by only looking at the basic needs of the machine and consider such gizmos as redundant.

Simple Generic Circuit Diagrams.

The following are basic wiring diagrams for printing as a starting point. The following selection of basic drawings are given. They are 800 x 600 pixels. They do not include the colour codes, as all motorcycle manufacturers differ.

These give the basics for most common bikes.

Print direct, or Copy and paste, or import them into any simple paint package so you can modify them, then go from there.

It is always preferable to use the original manufacturers wiring diagram for the engine used. If no wiring diagram available, choose the nearest for your bike from the above diagrams. The main items to look for are the type of alternator, and the type of points or electronic ignition used.

The main clues from the bike are the internal wiring of the alternator, the number of

wires on the rectifier/regulator. Also study the components available for the electronic ignition if fitted.

[1 a single cylinder with points ignition and direct lighting.](#)

[2 a single cylinder with points ignition and battery lighting.](#)

[3 a single cylinder with electronic ignition and direct lighting.](#)

[4 a single cylinder with electronic ignition and battery lighting.](#)

[5 a twin cylinder with points ignition and two plugs per coil.](#)

[6 a twin cylinder with points ignition and two ignition coils.](#)

[7 a twin cylinder with electronic ignition and two plugs per coil.](#)

[8 a twin cylinder with electronic ignition and two ignition coils.](#)

[9 a four cylinder with points ignition and two plugs per coil.](#)

[10 a four cylinder with electronic ignition and two plugs per coil.](#)

[11 a trike with four cylinder motorcycle engine.](#)

[12 a trike with car engine and points.](#)

[14 A very basic Harley wiring diagram. No indicators.](#)

[15 a car with points ignition and basic lighting.](#)

[16 a car with simple electronic ignition and basic lighting.](#)

[17 a typical basic motor boat .](#)

For many small bikes without advance and retard on electronic ignition units, such as motocross and mopeds and small scooters, then see also the 'A Builders guide to alternative electronic ignition', available via the authors website.

Finally,

From a simple eight wire circuit for a trials machine, to full blown systems using an aircraft engine, to touring bikes with hi-fi and Christmas tree lighting, or a fuel injected V12 trike almost anything is possible.

The main things to keep in mind are always carefully check the original wiring first, and keep to original manufacturers colours where possible. If complex systems such as fuel injection are daunting, then go slowly and replace each wire one at a time.

Always use separate circuits wherever possible, as these are easier to fault find, and to easily check each circuit one at a time.

For a standard bike, it is usually easier to do a full rewire than to repair a badly corroded or damaged original loom.

That's about it. More will be probably be added via the website updates as time passes, but this will do for now. The heavy stuff has been left out, especially the advanced projects being developed for the JP series.

Whatever is done, innovation is the definitive approach to design, but a learning curve should be expected before total creative freedom can be expected to bear fruit. Learning does not mean following others like a sheep. Always improve skills as seen fit, though careful, well paced steps leading towards the ultimate custom machine. Keeping eyes and mind open will allow the builder to glean all possible advantages towards a better machine.



Building a mental library of knowledge and skills will eventually express itself with flourish throughout the evolution of a project. Whatever learning is achieved, it is often of use in creating your own skills, approaches, designs and techniques.

It is very important not to rush a wiring loom. A cuppa tea is often the most important item, as it gives time to think things through, carefully.

Style.

No one should presume to tell the builder what the machine should look like, but asking various people will help decide if the rest of the world will be able to come to terms with the machine.

When designing a machine, consider trying to integrate the whole, so that a running motif or theme is applied across the whole machine. There are many alternatives to dangling wires.

Do not become a fashion victim. Always remember that so-called 'good taste' usually appears when imagination dies.

Science and technology can help, but the art form must grow from the dream, with inspiration to make it possible and occasionally that which makes all life worthwhile, the dream coming true, just the way it's imagined or even better.

All testing should be conducted with the intention of making the next machine even better.

An open approach to design will occasionally fail, but the failures will also lead towards better machines.

Please do not create anything which could bring motorcycles into disrepute.

Riding with a big grin can cause 'flies stuck in the teeth syndrome'.

Motorcycles and trikes have been with us for a century and show every chance of being even better in the future. Whatever is done and whatever materials may be used today, the design has probably been done before. The above information is not the only way to make a machine and there is nothing in this monograph which has not been done before, where most standard applications of technology can be seen at any bike shop or custom show. It is the way ideas are combined which can often improve a design.

Everyone will have a different approach according to personal preferences and engineering and design backgrounds. Innovation is a wonderful and often definitive approach to design, but a learning curve is needed before an excellent machine is crafted. For artists and visionaries who dream much further than most, this may involve a lifetime to develop and ride total creative freedom.

Learning does not, and should never mean following others like sheep. Always improve skills as seen fit, though careful, well paced steps leading towards the ultimate machine. If this monograph does not offer what is needed, then glean what is needed and break away and go for gold.

Please feel free to email the author.

There is no point in building such machines if the builder does not enjoy riding them. Always take every opportunity to enjoy the ride, as this is the ultimate goal of such processes. Always carry a notebook, because further improvement is often just another ride away.

If the machine is so radical that it gets strange looks from others, always smile when parking up, and engage in polite conversation, for the perception of others is always welcome. A radical machine is often a conversation starter, so use the occasion to advantage. The stranger may well be an old biker to whom you can enlighten to the advantages of new ideas, or who may offer the advice of many years. They may want to have their photo taken sitting in it. You may be invited to the next local bash.

If a very radical machine, you may be followed by police vehicles for a few miles, so get the paperwork sorted, but usually they just want to look and have a chat, so ride politely, and do not bullshit. When a particularly good machine is built, life becomes much better. A JP machine was invited into the lounge of a hotel, and was later chased for miles across Bordeaux roads to end up in an impromptu photo session by many excited French bikers. Life is for living.

I hope you have as much fun building and riding as I do. J.P. :)

Having read this far, the reader will hopefully have decided to venture beyond most wiring horizons.

Welcome.

End.

J.P.

I am often found helping out with the electrics in some local motorcycle shops, just to keep my hand in and to build a few custom wiring looms, from mopeds, through dirt bikes and full blown customs. Even a recent V12 efi trike was not so daunting as one would expect.

My main work is fixing common problems, but as the customer does not always want to buy a new item, then I rebuild switches and even locks.

I now do a lot of replacement CDI units for small bikes using C90 components and this is also described in my website for those who don't want to spend 100 quid when a fiver will do the same job.

Dirt bikes occasionally need lights, so adding a secondary lighting coil to MX machines is common, and an AC horn from a French moped or similar.

I am available for building custom wiring looms in the Plymouth England area and these come in two forms, - a rebuild of a standard loom, modifying where needed, or a completely new custom loom from 80 quid, which includes servicing of switches and other relative components. Use the e-mail address for more info.

Marine.

In many ways, parts of this monograph also applies to motor boats, but my marine guide (I'm a plant and marine engineer by trade) is still under construction. The waterproofing of off road motorcycle needs is not dissimilar to marine needs insofar as wet and vibration, but the corrosive effects of salt water add special requirements. The modern electronics proliferating in the marine industry make good electrics an even more important need. When added the needs of traditional and satellite navigation, radio detection, cooking, electric seating, engine management, winching, mast load gauges, solar charging and automatic bilge pumps, even television surveillance of the often compact engine compartment, then the aspects from my builders guide to van design are also applicable. The days of simply hand cranking a diesel to get back to harbour is long gone, unless you know and cherish this important feature of simplicity. My marine wiring monograph may be posted if sufficient requests.

SKETCH
OF THE
ANALYTICAL ENGINE

INVENTED BY
CHARLES BABBAGE, ESQ.

By L. F. MENABREA,

of Turin
OFFICE OF THE MILITARY ENGINEER

WITH NOTES BY THE TRANSLATOR

This book is sold for the sole purpose of supporting two wheel research. This has far to go, as the motorcycle is not yet a perfect machine. If you found this monograph useful and build any machine, feel free to Email.

Feedback is always welcome and will help to refine this monograph, with the intention to make building easier, more adaptable and available to all. This is a temporary edition to support the main monographs on motorcycle development. The intended book will be forthcoming if the research is accomplished, in about ten years. Much has been left out of this beginners guide, including

stabiliser systems, electronic gearchanges, head-up displays, and various camera and computer interfacing. The intended book will hope to be definitive work across the design, manufacture and testing of two wheel machines, and presently about half way through at half a million words, needing much paring.

Funding is fundamental to making the JP programme work, hence the need for this book. Bikers are usually decent people, so send a donation, as this directly supports research on a minimal budget. All profits directly support research and all honest donations welcome. Consultancy available for most types of machines.

For those wishing the author to design and build a dream machine, a technology demonstrator or even a two wheeled exhibition piece, any design will be considered.

Lectures also available, for art colleges to manufacturers.

The author is available for custom rewires for most bikes and trikes.

The ideas touched on in the text are deemed suitable for beginners, but are just the tip of the programme. The main of the programme hopes to develop the various future, truly radical machines and advanced systems needed to integrate man and machine for a variety of possible future scenarios.

Present projects (2001) include JP8a single seat designed in steel, with various engines, tyre sizes, rim and alternate brakes, plus hubcentred, antidive, advanced single sided front and rear suspension, linked and unlinked, possibly active suspension and geometry if programme has adequate funding and designed to include a number of radical advances as well.

Because the advanced chassis in steel was too heavy, being most as heavy as a standard bike chassis, the present project (2005) JP8b in composites is as an ultra-light slalom development machine using some very radical thinking, but retaining the hub centre steering and single sided rear end, but loosing most of the weight of the chassis in between the wheels. No, I have not bolted the suspension to the engine, as my tests with this type of chassis does not give a very level running platform.

This new chassis concept can then finalise the most important area of research, first developed and ridden on the JP4 and JP5. This requires much higher funding, hence these monographs. JP9 will be it's dual seat, full enclosed version. JP10 the road legal shakedown chassis and JP11a/b technology demonstrators, which will hopefully be the two definitive final forms of the final JP-FCM future concept machines, which this programme is working towards. Few traditionalists will approve.

Look around you, it was innovators like Babbage and Ada Lovelace, then Tomy Flowers and Alan Turing for the computer. See opposite.

Edison with sound and light. From the cup holding your coffee, to the glass window, seat covers, paper, pen, they all needed ordinary people with a dream of inspiration,

who created just about everything you now use. Too few people innovate and build customs, their effects on the environment is minimal, while their effects on human nature is liberating. Things won't get better unless those who can make better machines have the chance to do so.

If we all blindly follow those who think they know better, then, heaven forbid, we may even end up in a world where all cars begin to look alike, and the only options will be the exciting variations of cup holders or other such facile crap. If (when) this happens we will know we are dumbed down ready to become consumer sheep, fit only to graze in malls. No multi national can create true, radical innovation, unless they learn it or buy it from those who have the spark needed to start like the reader.

History is littered with innovators in philosophy, sociology, religion, economics, science, and of course, applied technology.

There is no point writing monographs like this if they cannot be used. Always use your vote, even if only to keep politicians and bureaucrats from making our lives constrained and boring against our will. Human nature must always ensure its creativity from a world dominated by (m)asses of corporate 'logo based life forms' and parasitic lawyers. Never vote for anyone who wants 'type approval', excessive paperwork or restrictions of custom machines for road use.

The price of freedom is eternal vigilance.

Know your roots, aspirations and abilities, and always protect them.

This monograph is sold for the sole purpose of supporting two wheel research which has far to go to take advantage of present levels of technology. Most motorcycle development remains wedded to traditional design. The Longbow and JP series have hopefully shown that there can be alternatives.

Begging.

Begging is the bottom line of this work. Being just one of the many long term unemployed English science graduates with a strong engineering background in nuclear, marine and other spheres, the author would like a job. A job teaching engineering or creating composite machines would be most tempting.

Most of the vast numbers of 'begging bowl innovators' have ideas, so please help. British venture capital is unfortunately an oxymoron, a joke comparable with our railways and education system.

Working on a begging level is an eye opener, requiring innovation to make things happen. Each JP research machine needs funding just to build, with each carefully considered machine having to develop many innovative ideas. The two JP7 chassis cost almost too much.

Funding is fundamental to a research programme, hence this monograph. So please offer a donation. Send what you think it's worth, as this also gives feedback.

If you are embarrassingly rich, please be so kind as to sponsor the research. Just three thousand pounds a year will eliminate delay, allowing the final forms to be developed quicker, and thus be more refined and subtle. Ten thousand pounds a year donations or simply materials supply underwriting will allow headlong path to a truly innovative form of two wheel transport. For those wishing the author to design and build a dream

machine, a technology demonstrator or even a two wheeled exhibition piece, or something from the above text, any design can be considered.
Sponsorship of the motorcycle programme also welcome. Full sponsorship will receive an exclusive JP10/FCM, either in road legal, or 24hr race form.
If nothing happens and the Longbow or JP7 have no public support, they will be allowed to die according to simple Darwinian processes.

The level of information offered in this monograph is exemplified with machines such as the JP7, integrating various innovative forms of electrics and electronics such as interactive stabilisers and head-up display. They were nice to ride, but should not be considered a definitive design, merely working examples of some aspects of the design aspects on which this monograph is based.

The more feedback, the more likely the author will put pen to paper.

The author would like a job. Please consider this monograph a CV.

Thanks,
John. Partridge. B.Ed. B.Sc. etc.

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Britain for the British. Now and For Ever.



jhpart at btinternet.com



Website at: www.btinternet.com/~jhpart/index.htm



The authors favourite electrical component supplier will added as soon as permission has been given. Until then, consider searching under "vehicle or wiring or products or ilkeston or derby "

Companion monographs by the author, from the same website.

A Builders Guide to Motorcycle Design.

A Builders Guide to Composite HPV Cycle Design.

A Builders Guide to Composite Motorcycle Design.

A Builders Guide to Trike Design.

A Builders Guide To Survival Knife Design.

A Builders Guide To Survival Kit Design.

A Builders Guide To Camper Van Design.

A Builders Guide To Basic Wind tunnel Design.

A Builders Guide to motorcycle mechanics: Basic, Intermediate and Advanced.

And many other monographs.

Other books which could be published include:

A lateral look at innovation. From Polynesian monkey traps to BV141.

An approach to preventing design stagnation in small businesses. Early draft.

A history of motorcycle design, its roots and future. 200,000 words, a 1990 draft basis of a thesis in

motorcycle development in html Via web site.

Ergonomics and control possibilities for single track vehicles.

Building the Future: Development possibilities for single track vehicles. Compilation.

Fundamental corporate design stagnation, and the rise of the car cup holder.

Social hurdles leading to the failure to find qualified staff. A few case histories.

Always try to improve society rather than just take from it. Until then, lawyer stuff. Copying or duplication of this material is prohibited without written permission of the author. The contents is for information only. No responsibility is accepted for any damage or any injury caused by the above information. Errors and omissions excepted. All trade marks acknowledged.

No-one should try building machines without reasonable abilities and know that injuries can ensue from the materials, tools and from test riding of machines.

This is a re-write of a 1985 article by the author.

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