A

AC Inverter - An electrical circuit which generates a sine-wave output (regulated and without breaks) using the DC current supplied by the rectifier-charger or the battery. The primary elements of the inverter are the DC/AC converter, a regulation system and an output filter.

A/D Converter (ADC) Analogue/Digital Converter. A device which converts continuously varying analogue signals into a binary coded digital form.

Acid - A proton donor. A compound containing hydrogen which dissociates in aqueous solution producing positively charged hydrogen ions (H^+). An acidic solution has a pH less than 7.0

Active material - The chemically reactive materials in an energy cell which react with each other converting from one chemical composition to another while generating electrical energy or accepting electric current from an external circuit.

Ageing - Permanent loss of capacity with frequent use or the passage of time due to unwanted irreversible chemical reactions in the cell.

AGM (Absorbtive Glass Mat) battery - A lead acid battery using a glass mat to promote recombination of the gases produced by the charging process.

Alkali - A compound which dissolves in water producing negatively charged hydroxide ions. Alkaline solutions are strongly basic and neutralise acids forming a salt and water.

Alkaline battery - A battery which uses an aqueous alkaline solution for its electrolyte.

Allotrope - Two or more forms of the same element in the same physical state (solid, liquid, or gas) that differs from each other in their physical and sometimes chemical properties. The term allotropy applies to elements only, not compounds. The more general term, used for any crystalline material, is polymorphism. See also isotope.

Ambient temperature - The average temperature surrounding the battery, typically air.

Amorphous - Without definite shape or structure, without crystalline structure.

Ampere (Amp) - The unit of current flow equal to one coulomb per second.

Ampere hours (Ah) or Amp hours - The unit of measure used for comparing the capacity or energy content of a battery with the same output voltage. For most batteries it defines the battery's C rate. For automotive (Lead Acid) batteries the SAE defines the Amp hour capacity as 20 times the current delivered for a period of 20 hours when the battery is discharged at 1 twentieth of the C rate until the cell voltage drops to 1.75 Volts.

Strictly - One Ampere hour is the charge transferred by one amp flowing for one hour. 1Ah = 3600 Coulombs. The true capacity of any battery is its energy content and this is measured in Watt-hours (Wh). It is the battery's Amp hour capacity multiplied by the battery voltage.

Ampoule battery - A battery in which the electrolyte is stored in a separate chamber from the cell electrodes until the battery is needed.

Analogue (Ana log) circuit - An electronic circuit in which an electrical value (usually voltage or current, but sometimes frequency, phase) represents something in the physical world. The magnitude of the electrical value varies with with the intensity of an external physical quantity.

Also - An electrical circuit which provides a continuous quantitative output (as opposed to a digital output which may be a series of pulses or numbers) in response to its input.

Anechoic chamber - A room whose walls do not reflect either electromagnetic or acoustic waves.

Anion - Particles in the electrolyte of a galvanic cell carrying a negative charge and moving toward the anode during operation of the cell. See also caption

Anisotropic - Showing differences of property or of effect in different directions.

Anode - The electrode in an electrochemical cell where oxidation takes place, releasing electrons. During discharge the negative electrode of the cell is the anode. During charge the situation reverses and the positive electrode of the cell is the anode.

ANSI - The American National Standards Institute publish standards for batteries jointly with NEMA. (See below)

Aqueous solution - Chemical components in liquid or gel form.

Arrhenius Equation - The relationship between the rate at which a chemical reaction proceeds and its temperature. In general terms, heat speeds up the chemical action.

Assembled battery - A battery composed of two or more cells.

Atomic Number - Specific to individual elements - represents the number of protons in the atomic nucleus. The same as the number of electrons.

Atomic Mass - The number of nucleons (protons and neutrons) in the atomic nucleus.

Auger analysis - Similar to ESCA but does not provide information on the chemical state (oxidation etc.) of the elements.

Authentication - Verification that an item is from an approved source and/or that it is able to meet its declared specification.

Avogadro's number (N_A) - The number of atoms in 12grams of Carbon-12 (definition) = 6.022×10^{23}. By extension, the number of particles in 1 mole of a substance.

B

Base - A proton acceptor. A compound containing hydrogen which dissociates in aqueous solution producing negatively charged hydroxide (OH^-) or other ions. Alkalis are bases and a basic solution has a pH greater than 7.0

Battery - Two or more electrochemical energy cells connected together to provide electrical energy.

Battery Management System (BMS) - Electronic circuits designed to monitor the battery and keep it within its specified operating conditions and to protect it from abuse during both charging and discharging.

Battery Monitoring - Sometimes confused with BMS (above) of which it is an essential part, these circuits monitor the key operating parameters (current, voltage, temperature, SOC, etc.) of the battery and provide information to the user.

Bobbin - A cylindrical cell design utilizing an internal cylindrical electrode and an external electrode arranged as a sleeve inside the cell container.

Bootstrap - To do something seemingly impossible using only the available resources. In the context of DC battery power circuits it means generating a DC voltage higher than the battery voltage.

British Thermal Units (BTU) - A unit of heat energy defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. One Btu is equal to about 252 calories, or 778 foot pounds, or 1.055 kilojoules or 0.293 watt hours.

Buck regulator - A switching regulator which incorporates a step down DC-DC converter. A transformer less design in which the lower output voltage is achieved by chopping the input voltage with a series connected switch (transistor) which applies pulses to an averaging inductor and capacitor.

Butler Volmer equation - Used by cell designers to predict the current which will flow in a battery. It is the sum of the anodic and cathodic contributions and is directly proportional to the surface area of the electrodes, increasing exponentially with temperature.

Button cell - Miniature cylindrical cell with a characteristic disc shape.

C

C Programming Language - The preferred programming language for embedded software used in many battery management applications. Robust, fast and powerful, it allows low level access to information and commands while still retaining the portability and syntax of a high level language.

C Rate - C is a value which expresses the rated current capacity of a cell or battery. A cell discharging at the C rate will deliver its nominal rated capacity for 1 hour. Charging and discharging currents are generally expressed as multiples of C. The time to discharge a battery is inversely proportional to the discharge rate.

NC is a charge or discharge rate which is N times the rated current capacity of the battery where N is a number (fraction or multiple)

C_N is the battery capacity in Amp Hours which corresponds to complete discharge of the battery in N hours (N is usually a subscript). Also written as the N-Hour rate.

Calendar life - The expected life time duration of a cell whether it is active use or in storage

CAN Bus - Controller Area Network The automotive industry standard for on-board vehicle communications. It is a two wire, serial communications bus which is used for networking intelligent sensors and actuators

Calorimeter - A device or chamber for measuring the heat generated by objects placed inside it.

Capacitance (C) - A measure of the ability of a device to store charge per unit of voltage applied across the device. **C=Q/V** Farads.

The capacitance of a parallel plate capacitor is given by $\mathbf{C = \varepsilon A/d}$ where **ε** is the permittivity of the dielectric, **A** is the area of the plates (electrodes) and **d** the distance between them.

1 Farad = 1 Coulomb per Volt. (Q / V)

The current through the capacitor is given by the relationship $\mathbf{i = C\, {}^{d}/_{dt} V(t)}$

Capacitor - A passive electrical device that stores energy in an electric field.

Capacity - The electric energy content of a battery expressed in "Watt hours". Batteries with the same output voltage also use "Ampere hours" for comparing capacities.

Capacity offset - A correction factor applied to the rating of a battery if discharged under different C-rates from the one rated.

Catalyst - A chemical agent which promotes or influences a chemical reaction without itself is being permanently changed by the reaction. Used in recombinant cells and fuel cells

Cathode - The electrode in an electrochemical cell where reduction takes place, gaining electrons. During discharge the positive electrode of the cell is the cathode. During charge the situation reverses and the negative electrode of the cell is the cathode.

Cation - Particles in the electrolyte of a galvanic cell carrying a positive charge and moving towards the cathode during operation of the cell. See also anion

CCA - Cold Cranking Amperes - A measure used to specify the cold cranking capability of automotive SLI batteries. For Lead Acid batteries it is the constant current a battery can deliver during a continuous discharge over a period of 30 seconds at -18℃ without the te rminal voltage dropping below a minimum of 1.2 Volts/cell.

CE - The CE marking indicates that the product has been designed and manufactured in conformity with the essential requirements of all relevant EU directives, and submitted to the relevant conformity assessment procedure.

Cell - A closed electrochemical power source. The minimum unit of a battery.

Cell balancing - The process used during charging to ensure that every cell is charged to the same state of charge. Also called "Equalisation".

Cell chemistry - The active materials used in the energy cell.

Cell reversal - A condition which may occur multi cell series chains in which an over discharge of the battery can cause one or more cells to become completely discharged. The subsequent volt drop across the discharged cell effectively reverses its normal polarity.

Charge - The process of replenishing or replacing the electrical charge in a rechargeable cell or battery. See also Electric charge

Charge acceptance - The ability of a secondary cell to convert the active material to a dischargeable form. A charge acceptance of 90% means that only 90% of the energy can become available for useful output. Also called Coulombic Efficiency or Charge Efficiency. See alternative definition below.

Charge carriers - The particle carrying the electrical charge during the flow of electrical current. In metallic conductors the charge carriers are electrons, while ions carry the charges in electrolyte solutions.

Charge efficiency - The ratio (expressed as a percentage) between the energy removed from a battery during discharge compared with the energy used during charging to restore the original capacity. Also called the Coulombic Efficiency or Charge Acceptance. See alternative definition above.

Charge pump - A power supply which uses capacitors instead of inductors to store and transfer energy to the output. A voltage doubler or Tripler.

Charge rate - The current at which a cell or battery is charged. Generally expressed as a function of rated capacity C.

Charge retention - The ability of a battery to retain its charge in zero current conditions. Charge retention is much poorer at high temperatures. See also Self Discharge

Charge, state of - The available or remaining capacity of a battery expressed as a percentage of the rated capacity.

Charge transport - The movement of electrical charge from one part of the system to another, occurring through the **drift** of ions under the influence of electrical potential difference. Also called **Electro migration**.

Chemical species - Atoms, molecules, molecular fragments, ions, etc., as entities being subjected to a chemical process or to a measurement.

CID Circuit Interrupt Device - A small mechanical switch which interrupts the current through an energy cell if the internal pressure exceeds a predetermined limit. Usually applied in small cells only.

Coin cell - Small cylindrical cell with a disc shape.

Conditioning - Cycle charging and discharging to ensure that formation (see below) is complete when a cell enters service or returns to service after a period of inactivity

Conductance - Strictly speaking the Conductance applies to resistive circuits and is the reciprocal of the Resistance. Battery manufacturers have their own definition which applies to the frequency dependent elements of the circuit, that is - **C= I/E** where C is the conductance, I is the test current applied to a component (the cell) and E is the in phase component of the ac voltage E producing it.(Compare with Ohm's Law **R=E/I**) Measuring the conductance of a battery gives a good indication of its state of health.

Conducting polymer - Plastic materials which have some of the properties of metals. Used as solid electrolytes in batteries. Also used in the construction of fuel cell membranes, capacitor electrodes and in applications requiring anti-static plastics. (See also Polymer below)

Constant current charge CC - A charging scheme which maintains the current through the cell at a constant value.

Constant voltage charge CV - A charging scheme which maintains the voltage across the battery terminals at a constant value.

Contacts - The battery output terminals.

Conversion Efficiency - The percentage of the input energy of a process that is converted to energy of the desired type.

Coulomb - A unit of electric charge. One coulomb (1C) is equal to the charge transferred by a current of one ampere in one second.

Coulomb Counting - A method of determining the state of charge of a battery by integrating the ingoing and outgoing discharge currents of a battery over time.

Coulombic Efficiency - The ratio (expressed as a percentage) between the energy removed from a battery during discharge compared with the energy used during charging to restore the original capacity. Also called Charge Efficiency or Charge Acceptance.

Coup de fouet (Whiplash) - A dramatic initial voltage drop when a battery is suddenly called upon to supply a heavy load. The voltage recovers after a short time once the electro-chemical discharge process stabilises.

Critical Temperature (Superconductor) **-** The temperature below which a superconducting material must be cooled in order to exhibit the property of superconductivity.(See below)

CSA - The Canadian Standards Association is a not-for-profit membership-based association serving business, industry, government and consumers in Canada and the global marketplace.

Curie point or **Curie temperature** - The temperature above which a Ferro magnets and some other materials undergo a sharp change in their magnetic properties losing their ability to possess a net spontaneous or remnant magnetization in the absence of an external magnetic field.

Current limit - The maximum current drain under which the particular battery will perform adequately under a continuous drain.

Current shunt - A current shunt is a low value resistance, whose value is accurately known, placed in series between the battery and the load. The voltage drop across the shunt is used to determine the value of the current using Ohm's Law. Used in series, it is not a shunt in the literal sense of the word. Its name derives from the fact that early ammeters could not handle high currents and the shunt was used to bypass most of the current around the meter.

Cut-off voltage - The specified voltage at which the discharge of a cell is considered complete. See also End voltage and Termination voltage

CVT - Constant Voltage Transformer

Cycle - A single charge and discharge of a battery.

Cycle life - The number of cycles a battery can perform before its nominal capacity falls below 80% of its initial rated capacity. See also Float life below.

Cylindrical cell - A cell in which the electrodes are rolled up in a spiral and placed into a cylindrical container.

D

D/A Converter (DAC) Digital/Analogue Converter - A device which converts a digitally coded signal into an equivalent analogue signal.

DC-DC Converter - An electronic circuit which takes a DC input voltage and converts it to a different, desired DC output voltage.

Deep cycle battery - A battery designed to be discharged to below 80% Depth of Discharge. Used in marine, traction and EV applications.

Deep discharge - Discharge of at least 80% of the rated capacity of a battery.

Delta V - The voltage drop which occurs in some cells, notably NiCad's, which indicates that the cell is fully charged.

Dendritic growth - The formation from small crystals in the electrolyte of tree like structures which degrade the performance of the cell.

Depth of discharge DOD - The ratio of the quantity of electricity or charge removed from a cell on discharge to its rated capacity.

Diamagnetism - The property of a substance which is repelled instead of attracted by a magnet. A diamagnetic material will be repelled from a magnet no matter what pole it is near. It is exhibited by all common materials, but is very weak and often swamped by stronger paramagnetic or ferromagnetic effects. Metals such as bismuth, copper, gold, silver and lead, as well as many non-metals such as graphite, water and most organic compounds are diamagnetic. See also Ferromagnetism and Para magnetism.

Dielectric - A non-conductor of electricity, such as an insulator, or a substance in which an electric field can be maintained with a minimum loss of power. The material used between two conducting plates to form a capacitor. When a dielectric or insulator is placed in an electric field, electric charges do not flow through the material but shift only slightly from their average equilibrium positions causing the dielectric to become polarised with a positive charge on one side and a negative charge on the other.

Dielectric Constant - Used to determine the ability of an insulator to store electrical energy. The dielectric constant is the ratio of the capacitance induced by two metallic plates with an insulator between them to the capacitance of the same plates with air or a vacuum between them.

Discharge - The change from chemical energy within the cell into electrical energy to operate an external circuit.

Discharge capacity - The amount of energy taken from the battery when discharged at the rated current and ambient temperature until the discharge end voltage is reached. Generally expressed in units of Watt hours (or Ampere hours for batteries with the same voltage).

Discharge rate - The current delivered by the cell during discharging. Expressed in Amperes or multiples of the C rate.

Discharge voltage - The voltage between the terminals of a cell or battery under load, during discharge.

DOD - Depth of Discharge (see above)

Dropout - In a voltage regulator, the lower limit of the AC input voltage where the power supply just begins to experience insufficient input to maintain regulation. The dropout voltage for linears is quite load dependent. For most switchers it is largely design dependent, and to a smaller degree, load dependent.

Dry Cell - A Leclanché cell with a gel electrolyte.

DST - Dynamic Stress Test. Accelerated battery life tests specified by the USABC. Cycling down to 80% DOD twice per day at different temperatures.

Duty Cycle - The load current or power a battery is expected to supply for specified time periods.

dT/dt - The rate of change of temperature with time. The rapid rate of temperature rise is used to detect the end of the charging cycle in NiMH batteries.

E

Earth Leakage Trip - See Ground Fault Interrupter

ECE-15 - The United Nations Economic Commission for Europe specification for urban driving cycle simulation.

E Rate - Discharge or charge power, in watts, expressed as a multiple of the rated capacity of a cell or battery which is expressed in watt-hours. For example, the E/10 rate for a cell or battery rated at 23.4 watt-hours is 2.34 watts. (This is similar to the method for calculating C-Rate.)

Elastomer - elastic or plastic materials that resemble rubber which resume their original shape when a deforming force is removed.

Electret - The electrostatic equivalent of the permanent magnet. Dielectric materials that have been permanently electrically charged or polarised.

Electric charge is a physical property of matter which causes it to experience a force when near other electrically charged matter. The charge may be positive or negative. Similar charges repel each other while opposite charges attract each other. The unit of electric charge is the Coulomb (C).

Electrochemical equivalent - The weight of a substance which is deposited by the passage of one coulomb of current.

Electrode - Conducting element within a cell in which an electrochemical reaction occurs.

Electrode potential - The voltage developed by a single electrode, determined by its propensity to gain or lose electrons.

Electrolysis - Chemical modifications, oxidation and reduction produced by passing an electric current through an electrolyte. See also Faraday's Law of Electrolysis

Electrolyte - A substance which dissociates into ions (charged particles) when in aqueous solution or molten form and is thus able to conduct electricity. It is the medium which transports the ions carrying the charge between the electrodes during the electrochemical reaction in a battery.

Electromotive Force EMF - The ability of an electrical source to deliver energy. It is the difference of potentials which exists between the two electrodes of opposite polarity in an electrochemical cell. Also known as the **Cell voltage**. The unit of EMF is the Volt.

Embedded System - A special-purpose computer system, which is completely encapsulated within the device it controls, usually performing a limited range of specific pre-determined tasks. This allows the use of simpler or cheaper dedicated microprocessors providing only the minimum functionality required by the application, or alternatively the entire processing power of the microprocessor can be focused on a single task. Battery Management Systems will normally be implemented with an embedded system.

EMC - Electromagnetic compatibility (EMC) is the ability of electronic and electrical equipment and systems to operate without adversely affecting other electrical or electronic equipment or being affected by other sources of electromagnetic interference. (RFI)

End voltage - The prescribed voltage that indicates that the discharge is complete. (see also Cut-off voltage)

Endothermic - Describes a chemical action in which heat is absorbed.

Energy Content - The absolute amount of energy stored in a battery expressed in Wh or Joules

Energy density - The amount of energy stored in a battery. It is expressed as the amount of energy stored per unit volume or per unit weight (Wh/L or Wh/kg).

Enthalpy - The amount of energy released or absorbed by a chemical reaction. The "Free Enthalpy" (also called the “Change in Gibbs free energy") in a reaction is the maximum amount of chemical energy available from a system that can be converted into electrical or mechanical energy and vice versa. (Discharge and charge respectively)

Entropy - A measure of the disorder of a system. Used as a measure of heat content.

EPROM - Electronically Erasable Programmable Read-Only Memory. Re-writable memory that does not lose data if power is lost to the system (non-volatile). Available in three types:

OTP One Time Programmable non-erasable.

Windowed (ultraviolet light erasable) used for prototyping and development work.

EEPROM Electronically Erasable Programmable Read-Only memory.

Equalisation - The process of bringing every cell in a battery chain to the same state of charge (SOC)

ESCA - Electron Spectroscopy for Chemical Analysis. Equipment using x-ray irradiation to identify the presence of individual chemical elements particularly for surface coatings and thin films where it can be used for selected element depth profiling. A machine typically costs about $750,000

ESD - Electrostatic Discharge

EUDC - Extra Urban Driving Cycle. European additional specification for urban driving cycle simulation.

EUROBAT - The Association of European Storage Battery Manufacturers. (Mainly Lead acid)

Eutectic - A mixture in such proportions that the melting-point is as low as possible, the constituents melting simultaneously.

EV - Electric Vehicle

Exercise - Commonly describes the discharging to one volt per cell and subsequent charging. Used to maintain or condition NiCad and NiMH cells.

Exothermic - Describes a chemical action in which heat is produced.

F

Farad - The charge in Coulombs necessary to change the potential between the plates of a capacitor by 1 volt. 1 Farad = 1 Coulomb per Volt. (Q / V)

Faraday cage - An enclosure with no apertures (holes, slits, windows or doors) made of a perfectly conducting material. No electric fields are produced within the Faraday cage by the incidence of external fields upon it or by currents flowing on the perfect conductor such that the perfectly conducting enclosure is a perfect electromagnetic shield.

Faraday constant- The magnitude of electric charge per mole of electrons or protons. It is equal to Avogadro's number times the charge on the electron. **$F= N_A.e$**

Faraday's Law of Electrolysis - The mass of a substance altered at an electrode during electrolysis is directly proportional to the quantity of electrical charge (measured in Coulombs) transferred at that electrode.

Faraday's Law of Induction - The induced EMF in a closed circuit is proportional to the rate of change of the magnetic flux through the circuit. See also Inductance

Fast charge - Charging in less than one hour at about 1.0C rate. Needs special charger.

FCC - The Federal Communications Commission is an independent United States government agency charged with regulating interstate and international communications by radio, television, wire, satellite and cable.

Ferromagnetism - The property of a substance which is attracted to a magnet. Iron, cobalt, nickel, gadolinium, dysprosium and alloys containing these elements are ferromagnetic. See also Diamagnetism and Para magnetism.

FET - Field Effect Transistor - A semiconductor device designed for fast, current switching applications.

Firmware - Instructions programmed into a micro-controller that controls its operation. A combination of hardware and software.

Flex Ray Bus - A fault tolerant, high speed data communications bus designed for complex automotive control applications.

Float charge - An arrangement in which the battery and the load are permanently connected in parallel across the DC charging source, so that the battery will supply power to the load if the charger fails. Compensates for the self-discharge of the battery.

Float life - The expected lifetime in hours of a battery when used in a float charge application. See also Cycle life above.

Flooded Lead Acid cell -In "flooded" batteries, the oxygen created at the positive electrode is released from the cell and vented into the atmosphere. Similarly, the hydrogen created at the negative electrode is also vented into the atmosphere. This can cause an explosive atmosphere in an unventilated battery room. Furthermore the venting of the gasses causes a net loss of water from the cell. This lost water needs to be periodically replaced. Flooded batteries must be vented to prevent excess pressure from the build-up of these gasses. See also Sealed Lead Acid (SLA) Cells which overcome these problems.

Flow battery - A battery in which the electrolyte flows or is pumped through the electrodes

Flywheel battery - A flywheel stores kinetic energy in a high speed (up to 100,000 rpm) rotating cylinder and is "charged" and "discharged" via an integral motor/generator. High power availability but low capacity.

Formation - Electrochemical processing of a cell electrode (or plate) between manufacturing and first discharge, which transforms the active material into its useable form.

FPGA - Field Programmable Gate Array. A microchip which can be made with thousands of programmable logic gates. Often used for prototype or custom designs, they permit short development times and low production costs.

FUDS - Federal Urban Driving Schedule specification for urban driving cycle simulation.

Fuel Cell - An electrochemical generator in which the reactants are stored externally and may be supplied continuously to a cell.

Fuel Gauge - An indication of the State of Charge (SOC) or how much charge is remaining in a battery. Also called a Gas Gauge.

Fuzzy Logic - A method of deriving precise answers from vague data.

G

Galvanic cell - An electrolytic cell in which chemical energy is converted to electrical energy on demand
Gas chromatography - The separation and identification of individual chemical components from a sample. A typical machine costs over $250,000.
Gas gauge - An electrical circuit which indicates the amount of charge remaining in a battery.
Gassing - The generation of a gaseous product at one or both electrodes as a result of the electrochemical action. In Lead Acid batteries gassing produces hydrogen and oxygen.
Gel cell - A battery which uses gelled electrolyte, an aqueous electrolyte that has been fixed by the addition of a gelling agent.
Gibbs free energy - See **Enthalpy**
GMR (Giant Magneto Resistance) a spintronic effect that produces a large change in resistance of the conducting layers that occurs when thin stacked layers of ferromagnetic and nonmagnetic materials are exposed to a magnetic field. "Giant" refers to its very large electrical signal. The technology is used to manufacture current and magnetic sensors.
Gravimetric Energy Density (WhKg) - The energy output per unit weight of a battery.
Gravimetric Power Density (W/Kg) - The power output per unit weight of a battery.
Ground Fault Interrupter - Also called an **Earth Leakage Trip** - A safety device which disconnects the mains power if an earth leakage (unsafe) condition is detected. A sensing coil detects fault currents from the live wire to the earth (ground) wire and switches off the power when a predetermined threshold is reached. The device is designed to protect the electrical installation from faults and does not sense fault currents from the live wire to any other earthed body. See also **Residual Current Device (RCD)** which also protects the user.
Ground Loop - An unintentionally induced feedback loop or crosstalk caused by two or more circuits sharing a common electrical ground.

H

Half Cell Reaction - The electrochemical reaction between the electrode and the electrolyte.
Hall Effect - When a fixed conductor carrying an electric current is placed in an external magnetic field perpendicular to the current there is voltage drop across the conductor at right angles to the current which is proportional to the magnetic field. Used to measure magnetic field strength.
Heavy Duty battery - An ill-defined battery characteristic. See Battery Performance.
Henry (H) - The unit of inductance. The inductance L in a circuit =1 Henry if the rate of change of the current of 1 Ampere per second in the circuit produces an EMF of 1 Volt.
1 Henry = 1 Weber per Amp (Wb / A)
Hertz (Hz) - The standard unit of frequency of one cycle per second.
HEV - Hybrid Electric Vehicle (See below)
Hibernation state - A state in which the the status of the various functions of a circuit has been saved in memory and the circuit has been switched off save energy. When power is reapplied, data taken from the memory is used to restore the circuit to the status it had before switch off. (See also "Standby state" below)
High Energy battery - An ill-defined battery characteristic. See Battery Performance.
High rate discharge - Discharge at a current of 2C or more.
Horse Power (Hp) - The rate of doing work. 1 Hp = 746 Watts or 550 foot pounds per second.
Hybrid Electric Vehicle (HEV) - A vehicle which has two forms of motive power one of which is electric.
Hydrometer - A device used for measuring the specific gravity of a fluid. In the case of lead acid batteries the specific gravity provides a measure of the state of charge of the cell.
Hygrometer - An instrument for measuring humidity. Often confused with a hydrometer.

Hysteresis - A property of physical and chemical systems that do not instantly follow the forces applied to them, but react slowly, or do not return completely to their original state. In the case of magnetic systems, when an external magnetic field is applied to a magnetic material, the material becomes magnetised absorbing some of the external field. When the external field is removed the material remains magnetised to some extent, retaining some magnetic field. See also hysteresis in batteries.

I

IEC - The International Electro technical Commission (IEC), founded in London in 1906, is the leading global organization that prepares and publishes international standards for all electrical, electronic and related technologies. See also Standards

IGBT - Insulated Gate Bipolar Transistor. It has the output switching and conduction characteristics of a bipolar power transistor but is voltage controlled like the MOSFET giving the high current carrying capability of the bipolar transistor but the ease of control of the MOSFET.

Immobilised electrolyte - A construction technique used in lead-acid batteries. The electrolyte (the acid) is held in place against the plates instead of being a free-flowing liquid. The two most common techniques are Gel Cell and Absorbed Glass Mat.

Impedance - A measure of the response of an electric circuit to an electric current. The actual value is frequency dependent. The current is opposed by the capacitance, inductance and resistance of the circuit.

Impedance tests - Determination of the battery's internal impedance by measuring the voltage drop across a cell when it carries a sample alternating current.

Inductance (L) - A measure of the ability of a device to store magnetic flux per unit of rate of change of current passing through the device. Measured in Henneries. 1 Henry = 1 Weber per Amp (Wb / A)
See also Faraday's Law of Induction
The voltage across the inductor is given by the relationship $\mathbf{v = - L \, {}^{d}/_{dt} I(t)}$

Inductive charging - A charger in which the charging current is induced by an external induction coil into a secondary transformer winding housed within the battery together with rectifying and charge control circuits.

Inductor - A passive electrical device that stores energy in a magnetic field

Infra-red radiation - The spectrum of the heat radiated by a warm body.

Inhibitor - A substance added to the electrolyte to prevent or slow down an unwanted electrochemical process. Used to prevent corrosion of the electrodes or the formation of dendrites.

Insert mouldings - Plastic parts containing metal inserts used to simplify product assembly and reduce costs. Inserts made from metal or other materials are placed in the mould prior to the injection of plastic. The plastic flows around the inserts and fixes their position.

Intelligent battery - Battery containing circuitry enabling some communication between the battery and the application or with the charger.

Intelligent charger - Charger which is able to react to inputs from an intelligent battery to control or optimise the charging process.

Intelligent Energy Manager IEM - A system for reducing the demands that power hungry applications place on the battery.

Intercalation - This insertion of ions into the crystalline lattice of a host electrode without changing its crystal structure.

Internal impedance - Resistance to the flow of AC current within a cell. It takes into account the capacitive effect of the plates forming the electrodes.

Internal resistance - Resistance to the flow of DC electric current within a cell, causing a voltage drop across the cell in closed circuit proportional to the current drain from the cell. Very low internal impedance is usually required for a high rate (high power) cell.

Inverter - An electrical circuit which generates a sine-wave output (regulated and without breaks) using the DC current supplied by the rectifier-charger or the battery. The primary elements of the inverter are the DC/AC converter, a regulation system and an output filter.

Ion - An atom or group of atoms which is electrically charged. Depending on how they were created - through release or absorption of electrons - ions can be either positively charged (**Cations**) or negatively charged (**Anions**). See also Ionisation

IP Code - Ingress Protection Rating. It consists of the letters IP followed by two digits. The first digit represents the degree of protection against dust and solids. The second digit represents the degree of protection against moisture and water.

IR drop - The voltage drop across a battery due to its internal impedance. See also Ohmic loss below.

I^2R loss - The energy generated or lost as heat due to the internal resistance of the battery. Also known as the Joule heating effect.

ISO - A network of national standards institutes from 148 countries, founded in 1946, working in partnership with international organizations, governments, industry, business and consumer representatives. The name, "ISO" was not intended as an acronym for an **International Standards Organisation** but was derived from the Greek word "*isos*" meaning "equal". See also Standards

Isotope - Atoms of the same element with the same atomic number (the same number of protons) but with different numbers of neutrons a hence different weights. See also allotrope.

J

Josephson Effect - The flow of electric current through nonconductive material when placed between two superconductors. Used to detect very weak magnetic fields.

Joule - "J" A measure of work, energy or cell capacity. For electrical energy, one Joule is one Amp at one Volt for one Second, or one Watt Second. 1 Wh = 3.6kJ. For mechanical energy one Joule is a force of one Newton acting over one metre i.e. One newton metre.

Joule heating - The I^2R loss or heating effect of a current **I** flowing through a resistance **R**.

K

Kalman Filter - A mathematical technique for deriving accurate information from inaccurate data.

Kelvin Bridge - An electrical circuit for measuring very low impedances such as battery internal impedance, contact resistance and resistance of circuit elements such as wires and cables. Also known as the Kelvin Connection for voltage sensing.

Keyed connectors - Plug and socket pairs with a unique mechanical profile which can only be mated with each other in a particular orientation and which do not allow mating with connectors of a different design.

L

LDO (Low Drop Out) Regulator - An LDO is a type of linear regulator. Dropout voltage is the minimum input to output voltage differential required for the regulator to sustain an output voltage within 100mV of its nominal value.

Leakage - The escape of electrolyte to the outer surface of the battery or cell.

Leclanché Cell - A zinc carbon or zinc chloride cell.

Lifetime Energy Throughput - The total amount of energy in Watt-hours which can be taken out of a rechargeable battery over all the cycles in its lifetime before its capacity reduces to 80% of its initial capacity when new.

LIN Bus - Local Interconnect Network An automotive industry standard for on-board vehicle communications. It is a single wire, serial communications bus which is used for networking intelligent sensors and actuators

Linear charger - Charger which uses a series regulator. The simplest and cheapest type but less efficient than a Switch mode charger.

Linear Regulator - A linear, or Series, regulator is a voltage regulator which uses a transistor or FET in series with the load, operating in its linear region, to subtract excess voltage from the applied input voltage, producing a regulated output voltage.

Lithium Ion Cell - A secondary lithium cell in which both the negative and positive electrodes are lithium insertion (intercalation) compounds. Also known as rocking chair, shuttlecock or swing cell.

Lithium Polymer Cell - A lithium ion cell with a solid polymer electrolyte.

Load current - The discharge current provided by a battery, or drawn by a battery powered device.

Long Life battery - An ill-defined battery characteristic. See Battery Performance.

M

Magnetic flux (Φ) - is a measure of the magnetic field strength. Measured in Webers

Magnetic flux density (B) - is the magnetic flux per unit area. **B = (Φ / A)** Teslas. The flux density resulting from a magnetic field is given by **B = μH** where **μ** is the permeability of the medium.

Magnetic field strength (H) - is a measure of the magnetic field surrounding a wire (or moving charge). **H = I / (2 π r)** Amps per metre, where **I** is the current in the wire and **r** the distance from the wire.

Magnetic Resonance Imaging (MRI) - A method of looking inside the human body without using surgery, harmful dyes or x-rays based on Nuclear Magnetic Resonance (NMR).

Magneto hydrodynamic Generator MHD - The production of electricity by passing a conducting fluid or plasma through a magnetic field.

Magneto motive Force (MMF) - is the strength of a magnetic field, or magnetic potential, in a current carrying coil of wire. It is the work that would be required to carry a hypothetical isolated magnetic pole of unit strength completely around a magnetic circuit and is equivalent to the current **I** multiplied by the number of turns **N** in the coil producing the field. It is expressed in units called ampere-turns (At). The **MMF = ampere-turns = NI**

Mass spectrometer - A device which produces a mass spectrum of a sample to find out its composition by ionising the sample and separating ions of differing masses and recording their relative abundance by measuring intensities of ion flux. Mass spectroscopy allows detection of compounds by separating ions by their unique mass. A typical machine costs around $250,000

Memory effect - Reversible, progressive capacity loss in nickel based batteries found in NiCad and to a lesser extent in NiMH batteries. It is caused by a change in crystalline formation from the desirable small size to a large size which occurs when the cell is recharged before it is fully discharged.

Mechanical charging - Charging by replacing one or more of the active chemicals in the cell.

Meissner effect - When a superconducting material is cooled below its critical temperature it will exclude or repel a magnetic field. A magnet moving by a conductor induces currents in the conductor. This is the principle upon which the electric generator operates. But, in a superconductor the induced currents exactly mirror the field that would have otherwise penetrated the superconducting material causing the magnetic field to be excluded and magnet to be repulsed. This phenomenon is known as diamagnetism (see above) and is so strong that a magnet can actually be levitated over a superconductive material.

Metal hydride - A metallic compound which is able to absorb hydrogen. Used as the negative electrode (anode) of a Nickel Metal Hydride battery.

Micro cycles - Rapid, shallow charge and discharge cycles which occur in automotive battery applications, particularly those which involve regenerative braking.

MISRA - Motor Industry Software Reliability Association.

Mole (n) - The amount of substance of a system that contains as many "elemental entities" (e.g., atoms, ions, electrons, molecules) as there are atoms in 12 grams of carbon-12 (Avogadro's number of particles). It is an amount, not a physical quality. 1 mole of a pure substance has a mass in grams equal to its molecular mass (M).
Molar mass - The mass in grams of one mole (or 6.02 x 1023 molecules) of any chemical compound.
Monomer - A small molecule that may become chemically bonded to other monomers to form a polymer. From Greek mono "one" and meros "part".
Morphology - The microstructure of the solid phases of materials. The grain shapes and structure of crystals of the chemical components of a battery.
MOSFET - A Field Effect Transistor made using Metal Oxide Semiconductor technology. Controlled by voltage rather than current like a bipolar transistor. MOSFET's have a significantly higher switching speed than bipolar power transistors. Suitable for high power circuits, they generate almost no loss (little heat generation), enabling fast response, excellent linearity, and high efficiency. The positive temperature coefficient inhibits thermal runaway. (Degrades to an SFET - Smoke and Fire Emitting Transistor if subject to excessive voltages). See also IGBT.
MSDS - Material Safety Data Sheet. Information provided by battery or cell manufacturers about any hazardous materials used in their products.
Multiplexer - A multiplexer is a device which enables several communications links or signals to share a single communications channel. At the receiving end of the link a DE multiplexer separates the signals again. Various coding schemes are possible which enable the signals to be transmitted simultaneously or sequentially.

N

Nano - From the Latin word meaning "dwarf". One billionth or 10^{-9}. One micron = 1000 nanometres. One nanometre is about the diameter of 3 to 6 atoms (depending on the element).
Nanotechnology - Nanomaterial's (Nano crystalline materials) are materials possessing grain sizes on the order of a billionth of a meter. Used for electrodes and separator plates in NiMH and Lithium ion batteries and also in super capacitors. Their foam-like (aerogel) structure provides a very large effective surface area which can hold considerably more energy than their conventional counterparts.
Nano battery - Very small battery built using Nano technology. Of microscopic size 1 micron diameter they deliver 3.5 volts. The electrodes are ceramic or carbon particles and the electrolyte is a solid polymer impregnated in an aluminium oxide membrane.
Negative Delta V (NDV) - The NDV is the drop in the battery voltage which occurs when NiCad or NiMH cells reaches their fully charge state. Used to detect the end of the charging cycle in NiCad's.
Negative electrode - The electrode which has a negative potential. The anode.
NEMA - The National Electric Manufacturers Association in the USA publish standards for batteries jointly with ANSI. (See above)
Nernst equation - Used by cell designers to calculate the voltage of a chemical cell from the standard electrode potentials, the temperature and to the concentrations of the reactants and products.
Neural Network - A powerful data modelling tool that is able to capture and represent complex input/output relationships. It is used as a basis for self-learning systems.
Nominal capacity - Used to indicate the average capacity of a battery. It is the average capacity when batteries are discharged at 0.2C within one hour of being charged for 16 hours at 0.1C and 20± 5℃. (Or discharg e at 0.05C for automotive batteries - SAE) Definition depends on the conditions. See Ampere Hours Ah above
Nominal voltage - Used to indicate the voltage of a battery. Since most discharge curves are neither linear nor flat, a typical value is generally taken which is close to the voltage during actual use.
NRE - Non-Recurring Engineering costs. A onetime charge for design and implementation of custom battery packs or other products.

NTC - A thermistor with a negative temperature coefficient, whose resistance decreases with increasing temperature.

Nuclear fission - Occurs when the atomic nucleus splits into two or more smaller nuclei plus some by-products. These by-products include free neutrons and photons (usually gamma rays). Fission releases substantial amounts of energy (the nuclear binding energy). The neutrons released by the fission process may collide with other nuclei causing them in turn to undergo fission initiating to a chain reaction.

Nuclear fusion - A process in which two nuclei join together to form a larger nucleus and releasing energy. It takes considerable energy to overcome the repulsion between the two positively charged nuclei to force them to fuse. The fusion of lighter nuclei, which creates a heavier nucleus and a free neutron, will generally release even more energy than it took to force them together. It is an exothermic process which could produce self-sustaining reactions.

Nuclear Magnetic Resonance (NMR) - The interaction of atomic nuclei placed in an external magnetic field with an applied electromagnetic field oscillating at a particular frequency. Magnetic conditions within the material are measured by monitoring the radiation absorbed and emitted by the atomic nuclei. Used in MRI scanners and as a spectroscopy technique to obtain physical, chemical, and electronic properties of molecules.

O

OEM Original Equipment Manufacturer - A company with the prime responsibility for conceiving, designing, manufacturing and distributing a particular product line.

Ohmic loss - The voltage drop across the cell during passage of current due to the internal resistance of the cell. Also known as IR loss or IR drop.

Open circuit voltage OCV - The voltage of a cell or battery with no load attached measured with a voltmeter at room temperature.

Operating voltage - Voltage between the two terminals of the battery with a load connected.

Operational amplifier (Op amp) - A high gain DC amplifier with a voltage gain of 100 to 100,000 or more and a very high (ideally infinite) input impedance and very low (ideally zero) output impedance. Op-amps are the basic building block of linear integrated circuits used for analogue circuit applications. They have positive and negative inputs which allow circuits which use feedback to achieve a wide range of functions.

Opportunity charging - Intermittent charging from sources whenever or wherever power is available.

Opto-isolator - Also called **opto-coupler**. An isolation device using optical techniques (an LED transmitting across a small gap to a photocell) to isolate the electrical connections between a transmitter and a receiver. Used to pass signals between high voltage and low voltage circuits and to replace switches and relays. Having no electrical connection they also help to cut down on ground loops.

Osmosis - The diffusion of a solvent through a semi permeable membrane from a region of low solute concentration to a region of high solute concentration. The semi permeable membrane is permeable to the solvent, but not to the solute, resulting in a chemical potential difference across the membrane which drives the diffusion. The solvent flows from the side of the membrane where the solution is weakest to the side where it is strongest to equalise the concentration on both sides.

Over-charge - Continuous charging of the battery after it reaches full charge. Generally overcharging will have a harmful influence on the performance of the battery which could lead to unsafe conditions. It should therefore be avoided.

Over-current - Exceeding the manufacturer's recommended maximum discharge current for a cell or battery.

Over-discharge - Discharging a battery below the end voltage or cut-off voltage specified for the battery.

Over moulding - An injection moulding technique used to encapsulate and protect components or small sub-assemblies, usually by moulding a soft, flexible, cosmetically attractive plastic over the components which must be able to withstand the temperatures and pressures of the moulding process. Used for cable connectors,

gaskets, and for incorporating small components into cables. Two shot moulds may be used to provide soft plastic grips over a hard plastic shell. It provides rugged, almost unbreakable protection with built in strain relief.
Over-voltage - The difference between the actual potential at which an electrochemical reaction occurs, and its theoretical equilibrium potential.
Oxidation - The loss of electrons by a chemical species

P

Packaging - In a battery, the mechanical structure used to contain and protect its components (cells, electronic circuits, contacts etc.).
Parallel connection - The connection together of, two or more, similar cells to form a battery of higher capacity by connecting together all the cell terminals of the same polarity.
Para magnetism - The property of a substance which is attracted to a magnet. It is similar to ferromagnetism except that the attraction is weaker. When a paramagnetic material is placed in a strong magnetic field, it becomes a magnet as long as the strong magnetic field is present. But when the strong magnetic field is removed the magnetic effect is lost. Below the substance's Curie temperature a paramagnetic material becomes ferromagnetic. Para magnetism is exhibited by materials containing transition elements, rare earth elements and actinide elements. Liquid oxygen and aluminium are also examples of paramagnetic materials. See also Diamagnetism and Ferromagnetism.
Passivation layer - A resistive layer that forms on the electrodes in some cells after prolonged storage impeding the chemical reaction. This barrier must be removed to enable proper operation of the cell. Applying charge/discharge cycles often helps in preparing the battery for use. In other applications, passivation is used as a method of shielding a metal surface from attack.
Periodic Table of the Elements - A tabular display of the known chemical elements. The elements are arranged by electron structure so that many chemical properties vary regularly appearing in groups with common properties across the table. Each element is listed by its atomic number and chemical symbol.
Permanent charge - The charging current which can safely be continuously supported by the battery, regardless of the state of the charge.
Permeability (μ) - The measure of the characteristic of a medium to support the formation of a magnetic field. It indicates degree of magnetisation that a material obtains in response to an applied magnetic field. It is measured in units of Henries per metre **(H / m)**
Permittivity (ε) - The measure of the characteristic of a medium to resist the formation of an electric field. It gives an indication of how much electrical charge a material can store in a given volume. It is measured in units of Farads per metre **(F/ m)**
Peukert's equation an empirical formula that approximates how the available capacity of a battery changes according to the rate of discharge. The equation shows that at higher currents, there is less available energy in the battery.
Peukert number a value that indicates how well a battery performs under heavy currents. A value close to 1 indicates that the battery performs well; the higher the number, the more capacity is lost when the battery is discharged at high currents. The Peukert number of a battery is determined empirically.
pH - (potential (of) hydrogen) is a logarithmic measure of the concentration of hydrogen ions (H +) in a solution and, therefore, its acidity or alkalinity (basicity). **pH = -log[H +]**
The "pH" scale extends from 0 to 14 (in aqueous solutions at room temperature). A pH value of 7 indicates a neutral (neither acidic nor basic) solution. A pH value of less than 7 indicates an acidic solution, the acidity increases with decreasing pH value. A pH value of more than 7 indicates an alkaline or basic solution, the alkalinity or basicity increases with increasing pH value.

Photovoltaic cell - A device that directly converts the energy in light into electrical energy. Also called a photocell, a solar cell or a PV cell.

Photovoltaic effect - The generation of an electromotive force as a consequence of the absorption of radiation. In practice a current which flows across the junction of two dissimilar materials when light falls upon it.

Pilot Cell - A selected cell whose condition is assumed to indicate the condition of the entire battery.

Plates - The electrodes used in a flat plate cell.

PNGV - **P**artnership for a **N**ew **G**eneration of **V**ehicles. A partnership between government, industry and academia in the USA to improve all aspects of automotive design in which batteries figure highly.

Polarisation - The change in the potential of a cell or electrode from its equilibrium value caused by the passage of an electric current through it. There are two irreversible electrochemical components, the "electrode polarisation" at the electrodes and the "concentration polarisation" in the electrolytic phase plus an ohmic loss component due to the electrical resistance of the cell. Also due to the build-up of gas bubbles on the electrodes.

Polarity reversal - Reversal of the polarity of a battery or cell due to over discharge.

Polymer - Strictly it is a substance made of long repeating chains of molecules called monomers which may be identical or different. The term polymer is often used in place of plastic, rubber or elastomer. In battery technology "polymer" usually refers to a solid (plastic) ionic conductor that is an electrical insulator but passes ions. (See also Conducting Polymer above)

Polymorphism - The ability of solid materials or compounds with the same chemical composition to exist in more than one form or crystal structure giving rise to materials with different physical or chemical properties. When the material consists of a single element, the property is known as allotropy.

Polyswitch - A resettable fuse. (See below)

Positive electrode - The electrode which has a positive potential. The cathode. Electric current from this electrode flows into the external circuit.

Pouch cell - A battery or cell contained in a flexible metal foil pouch.

Power density - The amount of power available from a battery. It is expressed as the power available per unit volume or per unit weight (W/L or W/kg).

Power Net - The standard proposed for next generation of automotive batteries. Nominally 42 Volt systems.

Power transistor - A high current, bipolar transistor controlled by the current through the gate. Used in linear (series) regulators as the voltage dropper between the unregulated voltage input and the regulated output. Also used as a high current switching device in control and protection circuits. Needs a high current to turn it on and is slow to turn off and its negative temperature coefficient makes it prone to thermal runaway. For these reasons it was mostly superseded by MOSFETs in high power battery switching applications. See also Thyristor and IGBT.

Ppm - Parts Per Million

Precursor - A chemical compound that participates in a chemical reaction which produces another compound.

Primary battery - A battery that is non-rechargeable.

Prismatic cell - A slim rectangular sealed cell in a metal case. The positive and negative plates are stacked usually in a rectangular shape rather than rolled in a spiral as done in a cylindrical cell.

Progressive dies - Multi-stage stamping tools for producing complex metal components from flat metal strip in a hydraulic or eccentric press. The die consists of two or more stages each of which carries out punching, drawing or folding operations with each down stroke of the press. Between each stroke, the strip moves from stage to stage through the die. Complex profiles and three dimensional shapes can be built up from a series of simpler operations which take place progressively at each stage as the strip passes through the die.

Protection - A facility incorporated into battery packs to protect the cells from out of tolerance working conditions or misuse.

PTC - A thermistor with a positive temperature coefficient, whose resistance increases with temperature.

PPTC - A Polymeric Positive Temperature Coefficient device. It is a non-linear thermistor, more commonly called a resettable fuse.

Pulse charger - Versatile, hybrid charger having some of the advantages of both switch-mode and linear chargers. More costly than both.

Pulse discharge - A high rate discharge, usually of 1 second or less.

Q

Quick charge - Charging in three to six hours at about 0.3C rate. Needs special charger.

Quiescent current - The current which continues to be drawn from the battery when the application it powers is in standby or hibernation mode.

R

Ragone Plot - The graphical illustration of the specific energy of a cell as a function of its specific power.

RAM cells - Rechargeable Alkaline Manganese cells.

RAPS - Remote-Area Power Supplies - Power systems deriving their energy from local solar or wind sources using a battery for energy storage and supplying the load through DC-DC converters or AC inverters.

Rate - When applied to cells it usually means the cells current carrying capacity.

Rated capacity - The specified capacity of a battery.

Reconditioning - One or more deep discharges below 1.0 V/cell with a very low controlled current, causing a change to the molecular structure of the cell and a rebuilding of its chemical composition. Reconditioning helps break down large crystals to a more desirable small size, often restoring the battery to its full capacity. Applies to nickel-based batteries. See also refurbishment (below)

Recombinant system - Sealed secondary cells in which gaseous products of the electrochemical charging cycle are made to recombine to recover the active chemicals. A closed cycle system preventing loss of active chemicals. Used in NiCad's and SLA batteries.

Recovery - The lowering of the polarization of a cell during rest periods.

Recycling - Reclamation of materials without endangering human health and the environment.

Redox - A contraction of the words "reduction" and "oxidation". The two chemical reactions on which cell chemistries depend.

Redox Battery - A battery in which the chemical energy is stored in two dissolved ionic reactants separated by a membrane.

Reduction - The gain of electrons by a chemical species.

Refurbishing - The repair of worn out or damaged batteries. This is not the same as reconditioning (see above).

Regenerative braking - This uses the electrical drive motor in an electric vehicle to act as a generator returning energy to the battery when overdriven mechanically by the vehicle wheels. This provides a powerful braking effect and at the same time captures energy which would otherwise be wasted or dissipated in the brakes.

Regenesys - A high power Sodium Polysulfide Bromine "Flow Battery".

Regulator - See Voltage regulator.

Relay - A mechanical switch operated by a solenoid.

Resealable safety vent - The resealable vent internal to a cell to release excessive internal pressure**.**

Reserve battery - Batteries which are stored in an inactive state without their electrolyte. They are only activated when needed by the introduction of the electrolyte. See also Water-activated batteries and Ampoule batteries.

Reserve capacity - The number of minutes at which the battery can be discharged at 25 Amps and maintain a terminal voltage higher than 1.75 volts per cell, on a new, fully charged battery at 80degrees Fahrenheit(27C). Defines a battery's ability to power a vehicle with an inoperative alternator or fan belt. Used for comparing automotive SLI batteries.

Resettable fuse - A fuse which protects against excessive current and temperature by interrupting the flow of current. After opening it will reset after the fault conditions have been removed but only after it has cooled. It requires no manual resetting or replacement. The "Polyswitch" is an example of this.

R**esidual Circuit Breaker** (**RCCB**), or **Residual Current Device** (**RCD)** - an electrical safety device which interrupts a circuit whenever it detects that the current is not balanced between the live (high voltage) conductor and the return neutral conductor. It can be used as a safety device by cutting off the supply voltage when it detects current leakage through the body of a person who is earthed (grounded) accidentally touching a live part of the circuit. See also Ground Fault Interrupter / Earth Leakage Trip.

Resistance welding - Resistance welding is a process used to join metallic parts with electric current. There are several forms of resistance welding, including spot welding, seam welding, projection welding, and butt welding.

Rest periods - Interruptions to the charging process to allow the chemical reactions in the battery to stabilise.

Reversible reaction - A chemical reaction which can be reversed to reconstitute the original components.

RFI - Radio Frequency Interference. Transmitted/emitted RFI affects other external equipment. Susceptibility measures the immunity of equipment from received RFI. See also EMC and Electromagnetic Radiation

RFID - Radio Frequency Identification. Small tags incorporating a radio transmitter which can be used to identify or track items of value.

Rocking Chair Cell- A lithium ion cell

RS232 connection - A standard for serial transmission of data between two devices.

RS485 connection - A standard for serial transmission of data between multiple devices.

S

SAE - Society of Automotive Engineers. The SAE Technical Standards Board issues and recommends industry standards. See also Standards

Safety vent - A safety mechanism that is activated when the internal gas pressure rises above a normal level.

Sampling Rate - The repetition frequency at which digital samples are taken of an analogue quantity.

Sealed cells - A cell which remains closed and does not release gas or liquid when operated within the limits of charge and temperature specified by the manufacturer. An essential component in recombinant cells.

Secondary battery - A battery which can be recharged and used repeatedly.

Self-discharge - Capacity loss during storage due to the internal current leakage between the positive and negative plates.

SEM (Scanning Electron Microscope) - Apparatus used to investigate the physical structure of cell components and surfaces. They typically cost about $500,000 or more.

Semiconductor - An insulator whose conductivity can be manipulated by the addition of impurities (doping), by introduction of an electric field, by exposure to light , or by other means.

Separator - A non-conductive semi-permeable film or grid to separate 2 electrodes to prevent them from contacting each other and short-circuiting but which allows the passage of ions through it.

Series connection - The connection of, two or more, similar cells in a chain to form a battery of higher voltage by connecting the positive terminal of each cell to the to negative terminal of the next cell.

Series regulator - Another name for a Linear regulator

Service life - The period of useful life of a battery before a predetermined end point is reached.

Shedding - The loss of material from the plates of Lead Acid batteries.

Shelf life - The duration a cell can be kept in storage and still retain its ability to give a specified performance. See also Battery Storage

Shrouded terminals - Terminals surrounded by an insulating shroud which prevents accidental contact with the terminal.

Shunt - A device which allows electric current to pass around another point in the circuit.

Shunt regulator - A voltage regulator which uses a transistor or FET, in parallel with the load, which shorts out the excess voltage when the applied input voltage exceeds a specified limit producing a regulated output voltage. It is a simple but lousy design.

Shuttlecock cell - A lithium ion cell.

Sintering - Heating a mixture of powdered metals, sometimes under pressure, to the melting-point of the metal in the mixture which has the lowest melting-point, the melted metal binding together the harder particles.

SLA Battery - Sealed Lead Acid battery. In sealed batteries the generated oxygen combines chemically with the lead and then the hydrogen at the negative electrode, and then again with reactive agents in the electrolyte, to recreate water. A recombinant system. The net result is no significant loss of water from the cell. See also Flooded Lead Acid cell.

SLA - Equipment used for rapid prototyping. See Stereo Lithography Apparatus below.

SLI Battery - Common automotive battery used for Starting Lighting and Ignition

Slow charge - Charging overnight in 14 to 16 hours at about 0.1C rate. Safe and simple.

Smart Battery - An intelligent battery which contains information about its specification, its status and its usage profile which can be read by its charger or the application in which it is used.

SMBus - System Management Bus. A two wire, 100 KHz, serial bus for interconnecting Smart Batteries which have built in intelligence, with their associated chargers or applications.

Solar cell - A photovoltaic cell. Solar cells convert sunlight energy into electric current. They do not store energy.

Solar panel - An array of photocells providing an increased output.

Solenoid - A coil containing an iron plunger which moves when a current is passed through the coil.

Solid State Battery - Cells with solid electrolytes. Lithium polymer cells are examples of this technology

SOC - State of Charge. See below.

SOH - State of Health. See below.

Specific Energy - Same as Gravimetric Energy Density (Wh/Kg)

Specific Gravity SG - The ratio of the weight of a solution compared with the weight of an equal volume of water at a specified temperature. It is used to determine the charge condition in lead acid batteries.

Specific Power - Same as Gravimetric Power Density (W/Kg)

Spintronics - A technology used in solid state devices which exploits the intrinsic spin of the electron and its associated magnetic moment, in addition to its fundamental electronic charge. Also known as magneto electronics.

Spiral Wound - Battery construction in which the electrodes with the electrolyte and separator between them are rolled into a spiral like a jelly roll (Swiss roll).

Stacked Electrodes -

Standard charge - The normal C/10 charge used to recharge a cell or battery in 10 hours. Other definitions (charging periods) also apply.

Standby power - A fully charged battery ready to take over supplying a load in case of emergency.

Standby state - A state in which the main functions of a circuit have been powered down to save energy, but power remains applied to the circuit ready to make a rapid restart. (See also "Hibernation state" above)

State of Charge- SOC - The available capacity of a battery expressed as a percentage of its rated capacity.

State of Health- SOH - A measurement that reflects the general condition of a battery and its ability to deliver the specified performance compared with a fresh battery. It takes into account such factors as charge acceptance, internal resistance, voltage and self-discharge. It is not as precise as the SOC determination.

Stereo lithography (SLA) - A Rapid Prototyping (RP) system for creating plastic parts directly from 3D CAD files. The RP model speeds design validation and is also finds use as a master pattern.

Stoichiometry - The branch of chemistry that deals with the numerical proportions in which substances react.

Storage life - The length of time a cell or battery can be stored on open circuit without permanent deterioration of its performance. See also Battery Storage

Studs - Threaded bolt connectors used on high power cells

Sulphation - Growth of lead sulphate crystals in Lead-Acid batteries which inhibits current flow. Sulphation is caused by storage at low state of charge.

Super capacitor - A capacitor that can store a large amount of energy. Also called Ultra capacitor or Booster capacitor.

Superconductivity - A phenomenon occurring below a very low, characteristic critical temperature in certain materials (superconductors), characterised by the complete absence of electrical resistance and the damping of the interior magnetic field (the Meissner effect). Superconductors can carry currents that will not decay.

Swelling - Distortion of cells caused by expansion of the active chemicals due to temperature and pressure effects.

Swing cell - A lithium ion cell

Switcher - A switch mode regulator.

Switch mode charger - Charger which uses a switch mode regulator. More efficient but more costly than a linear charger.

Switch mode regulator - A switching regulator is a voltage regulator which uses an output stage, switched repetitively on and off, together with energy storage components (capacitors and inductors) to generate a DC output voltage. Regulation is achieved through Pulse Width Modulation (PWM). Output voltages can be generated that are greater than or less than the input voltage and multiple output voltages can be generated with a single regulator.

T

Tabs - Flat connectors used on pouch cells.

Tafel equation - The relationship between the internal electrode potentials in a battery and the current which flows. This is an exponential relationship based on empirical results which quantifies the electrochemical reactions. It is analogous to the Arrhenius equation which quantifies the thermochemical process relating the temperature to the rate at which a chemical action progresses.

Taper charge - In quick chargers the charging current is progressively reduced in a controlled way by controlling the supply voltage. In slow chargers the voltage is fixed and the charging current reduces in an uncontrolled way due to increase in the cell voltage as the charge builds up.

Temperature cut-off - A temperature sensing method which detects heat rise in a cell at overcharge and switches the charger off or to a lower rate of charge.

Temperature sensor - An electronic device which provides a voltage analogue of the temperature of the surface on which it is mounted. A thermistor is an example.

Termination voltage - The maximum voltage which can be tolerated by a cell during charging without damaging the cell. The cell voltage at which the charging process should be terminated.

Tesla (T) - The unit of magnetic flux density. 1 Tesla = 1 Weber / metre^2

Thermal Capacity - The amount of energy required to raise the temperature of an object by one degree Celsius. Expressed in Joules/Kg.

Thermal fuse - A safety device which interrupts a circuit when it detects excessive temperature.

Thermal imaging - A photographic technique which displays the range of temperatures of a warm body in the form of a colour spectrum. Used as a design verification tool for detecting hot spots in battery and other equipment designs.

Thermal management - The means by which a battery is maintained within its operating temperature limits during charging and discharging.

Thermal runaway - A condition in which an electrochemical cell will overheat and destroy itself through internal heat generation. This may be caused by overcharge or high current discharge and other abusive conditions.
Thermistor - An electrical device whose resistance varies with temperature. They are used as temperature-measuring devices or in electrical circuits to compensate for temperature variations of other components.
Thyristor - Also called a **Silicon-Controlled Rectifier** or **SCR**, it is a solid-state high current semiconductor switching device similar to a diode, with an extra terminal which is used to turn it on. Once turned on, the thyristor will remain on (conducting) as long as there is a significant current flowing through it. If the current falls to zero, the device switches off. See also Power transistor.
Traction battery - A high power deep cycle secondary battery designed to power electric vehicles or heavy mobile equipment.
Transient response - The ability of an electrical or other device to respond faithfully to sudden changes to the input conditions.
Trickle charge - A continuous charge at low rate, balancing losses through local action and/or periodic discharge, to maintain a cell or battery in a fully charged condition. Normally at a C/20 to C/30 rate.
TÜV - TÜV Rheinland Group (TUV - Technical Inspection Association) is an international service company which documents the safety and quality of new and existing products, systems and services.

U

UL - Underwriters Laboratories Inc. - (UL) is an independent, not-for-profit product safety testing and certification organization based in the USA. UL marking indicates that the product conforms to the safety standards laid down by Underwriters Laboratories.
Ultra capacitor - See "Super capacitor" above.
Ultrasonic welding - Ultrasonic welding involves the use of high frequency sound energy to soften or melt the thermoplastic at the joint. Parts to be joined are held together under pressure and are then subjected to ultrasonic vibrations usually at a frequency of 20, 30 or 40 kHz.
UPS - Uninterruptible Power Supply
USABC - The United States Advanced Battery Consortium

V

Valence - The combining capacity of an atom expressed as the number of single bonds the atom can form or the number of electrons an element gives up or accepts when reacting to form a compound.
Venting - The release of excessive internal pressure from a cell in a manner intended by design to preclude explosion.
Voltage cut-off - A voltage sensing device which will end a charge or discharge at a pre-set voltage value.
Voltage limit - A voltage value a battery is not permitted to rise above on charge and/or fall below on discharge
Voltage regulator - A circuit which provides a fixed or controlled voltage output from a variable voltage input. Used in power supplies and chargers. Switching regulators , Linear regulators and Shunt regulators are the most common types.
Voltaic efficiency - The ratio (expressed as a percentage) between the voltage necessary to charge a secondary cell and the corresponding discharge voltage.
Volumetric Energy Density (Wh/L) - The energy output per unit volume of a battery
Volumetric Power Density (W/L) -The power output per unit volume of a battery
VRLA battery - Valve Regulated Lead Acid Battery

W

Ward-Leonard controller - A motor-generator system which uses a AC motor driving a variable voltage DC generator which drives a DC motor to provide a variable power transmission. Used for high power load testing.
Watt - A unit of power, the rate of doing work. Watts = Amps X Volts = One Joule per second.
Watt-hours (Wh) - A measure of the energy capacity of a battery. The amount of work done in one hour. 1 Wh = 3.6 kJ.
Weber (Wb) - The unit of the magniude of the magnetic flux. A flux density of one Wb/m^2 (1 Weber per square meter) is 1 Tesla
Well to wheel efficiency - The ratio between the mechanical energy ultimately delivered to the road wheels of a vehicle and the chemical energy content of the oil consumed in providing it. It is used to compare the fuel efficiencies of different methods of powering road vehicles and takes into account the refining process, the energy loss in the distribution process (in the case of hydrogen, the energy used to compress it) and the conversion efficiency of the vehicle's power unit.
Wet Cell - A cell with free flowing liquid electrolyte.

X

X-ray Crystallography - The use of the property of X-ray diffraction by crystals to determine their physical structure.

Y

Z

Zapping - A desperation measure to revive a shorted cell suffering from dendrites. A very high current, low voltage pulse from a large capacitor used in an attempt to vaporise the dendrites.
Zebra battery - A high temperature Sodium Nickel Chloride battery delivering high power.