Chapter 1

AUTOMOBILE ELECTRICAL SYSTEMS AND ELECTRONICS SYSTEM

Insulators, Conductors, and Semiconductors

Materials having very few free electrons are difficult to ionize as they do not readily allow electric charge to pass within them. These materials are termed **insulators.**

Conductors are materials in which atoms are surrounded by many free electrons and they normally exist in an ionized state.

Between insulators and conductors, there exists a group of materials in which ionization occurs to a small extent at room temperature. These materials are known as **semi-conductors**, which conduct electricity much better than insulators, but not like conductors.

As temperature is raised, semiconductors tend to conduct electricity better, releasing more free electrons through temperature induced ionization.
Semiconductor materials are very important to the electronics industry being the raw materials for the manufacture of devices like **transistors and diodes**.
Silicon is the best known of the semiconductors.

Voltage, Current, and Resistance

Voltage is the difference in charge between two points.
Current is the rate at which charge is flowing.
Resistance is a material's tendency to resist the flow of charge (**current**).

Series and Parallel Circuits

A vehicle's electrical circuits consists of a number of components connected between the vehicle's battery terminals constituting a circuit. Components in the circuit can be connected in series (end-to-end in a 'string'), so that same current flows in each (Fig. 1), or can be arranged in parallel so that the current divides between them (Fig. 2).

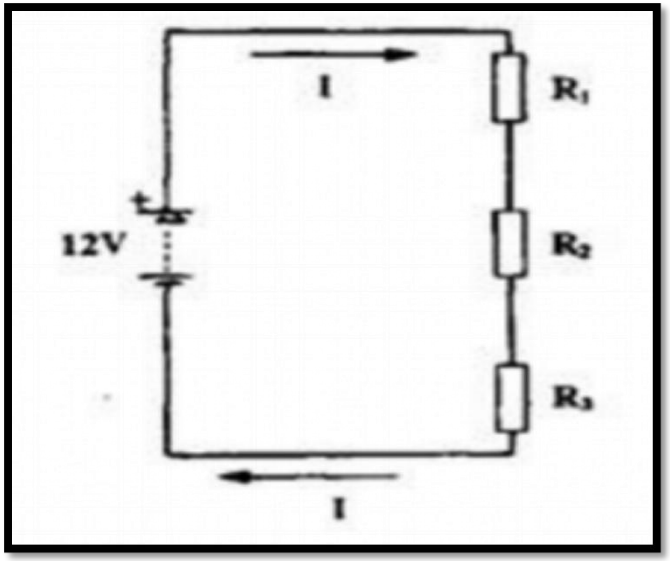


Fig. 1

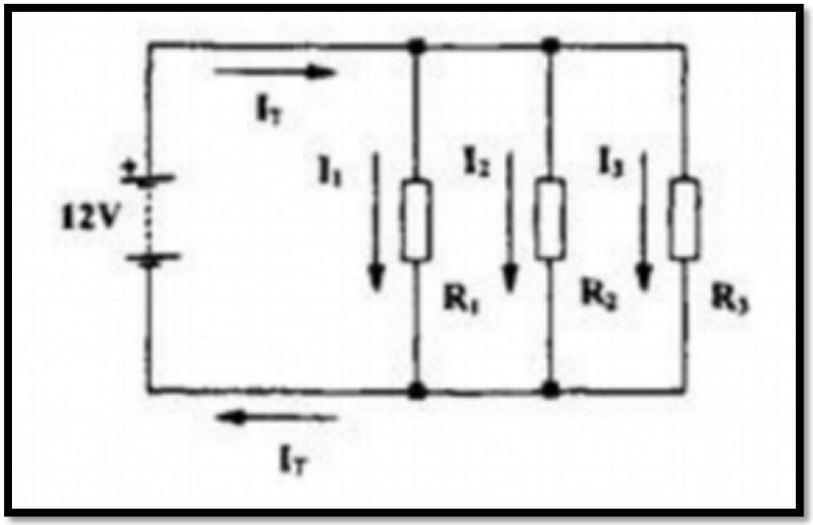


Fig. 2

Fig. 1 represents three resistors connected **in series**, and hence all carry the same current (I). The potential difference developed across each of the resistors may be calculated using Ohm's Law.

Thus, $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$

So the total applied voltage, $V_T = V_1 + V_2 + V_3 = (IR_1) + (IR_2) + (IR_3) = I(R_1 + R_2 + R_3)$

and the total resistance, $R_T = V_T/I = R_1 + R_2 + R_3$

Thus in a series circuit:

(i) The current is the same through all resistors.

(ii) The total potential difference is equal to the sum of all the individual potential differences.

(iii) The individual potential differences are directly proportional to the individual resis-tances.

(iv) The total resistance is larger than the largest individual resistance.

(v) The total resistance is the sum of the individual resistances.

Figure 2 shows three resistors connected **in parallel**. Voltage, Vt is applied to all of the resistors.

Therefore, $I_T = I_1 + I_2 + I_3$

and using Ohm's Law, $I_1 = V_T/R_1$, $I_2 = V_T/R_2$, $I_3 = V_T/R_3$

and so the total current, $I_T = V_T/R_1 + V_T/R_2 + V_T/R_3 = V_T\,(1/R_1 + 1/R_2 + 1/R_3)$.

The equivalent resistance R_{EQ} ($= V_T/I_T$) of a parallel circuit (in this case three resistances) is given by $I_T/V_T = 1/R_{EQ} = 1/R_1 + 1/R_2 + 1/R_3$

Thus in a parallel circuit:

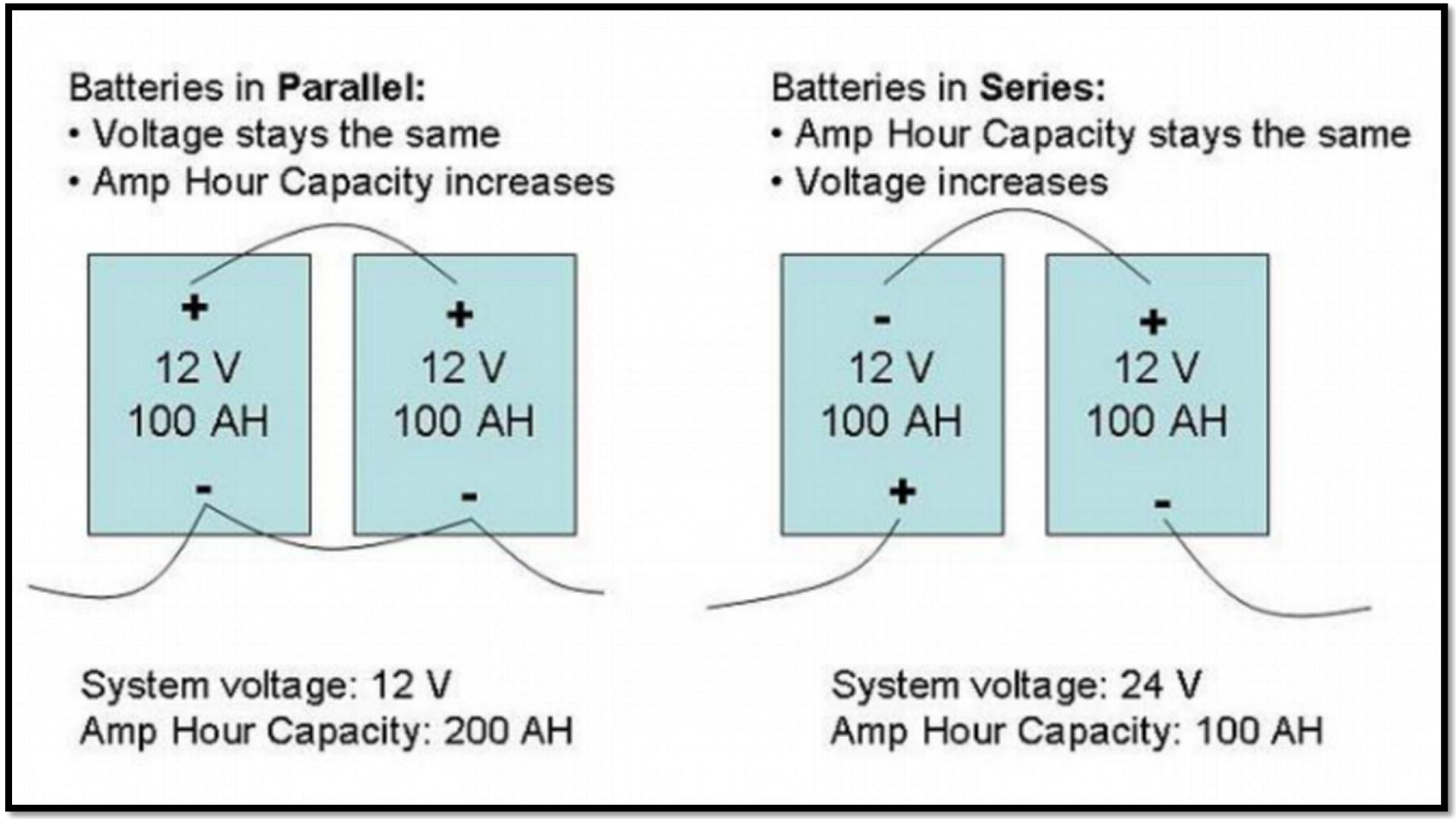
(i) The potential difference is the same across each resistor.

(ii) The total current in the circuit is the sum of the individual branch currents.

(iii) The individual branch currents are inversely proportional to the individual resistan-ces.

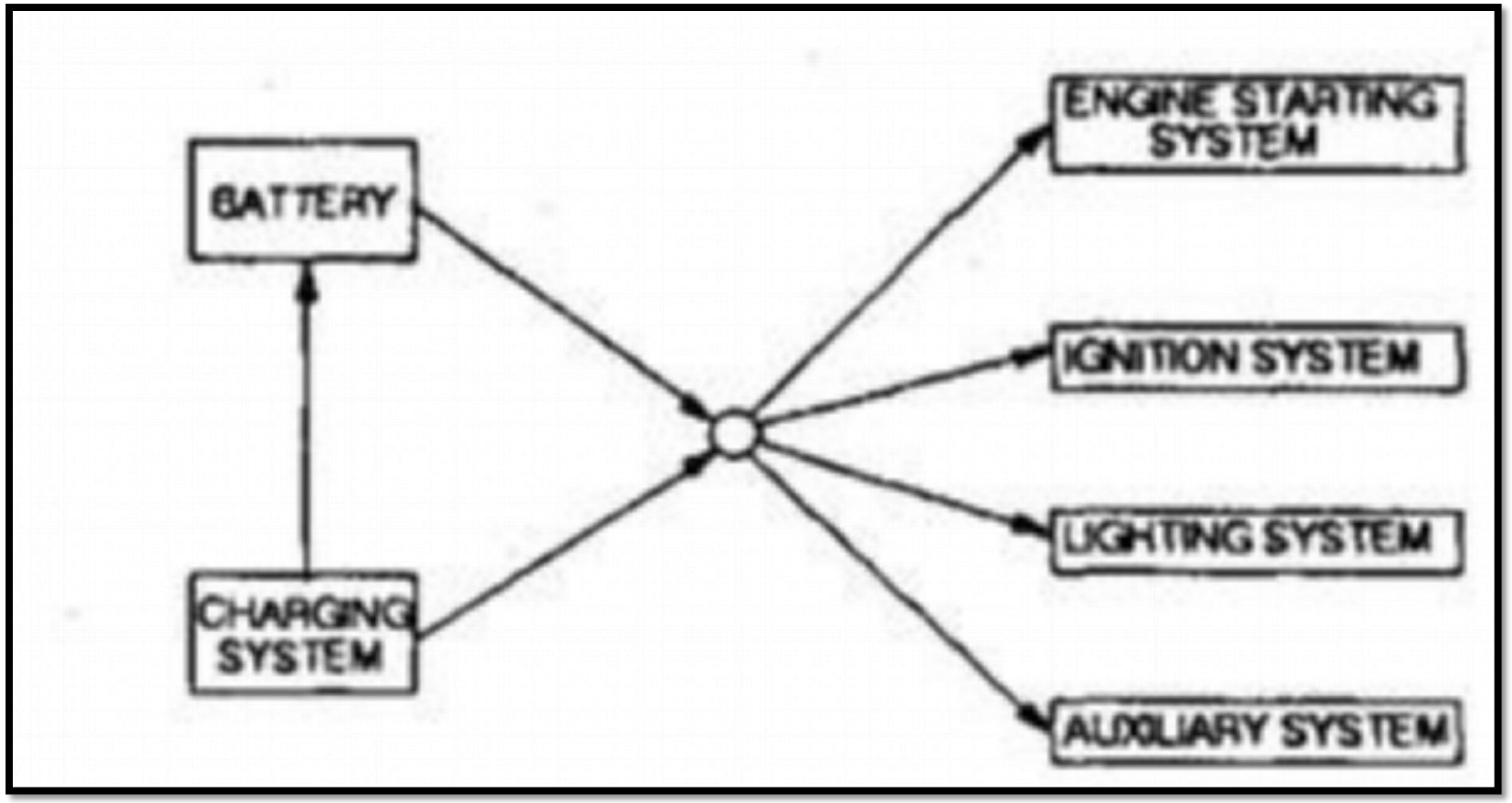
(iv) The equivalent resistance of the circuit is smaller than the smallest individual resistance.

12 Volt & 24 Volt system



Vehicle Circuits and Systems

Introduction



Types of cables and wires

“GPT” or “Primary” Wire

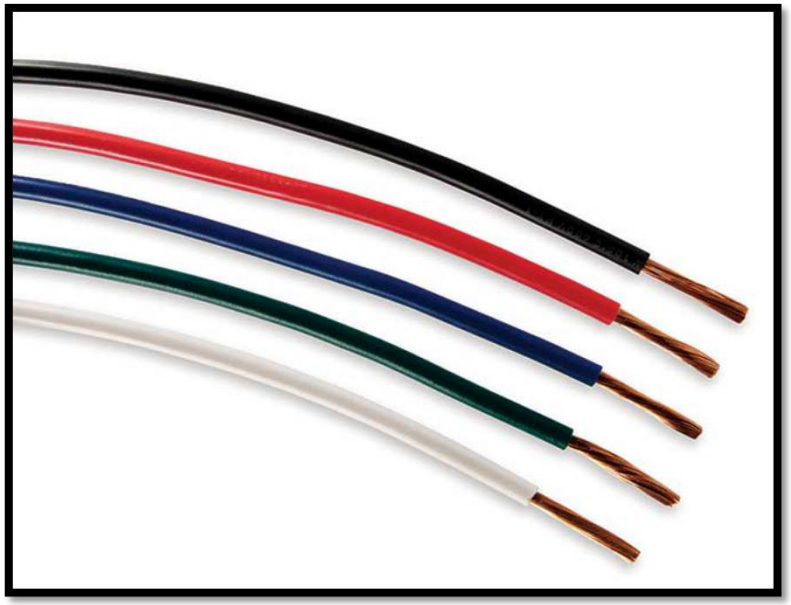
Primary Wire is ideal for general purpose wiring for passenger cars and light trucks, agricultural tractors, boats, buses, agricultural tractors, construction, locomotive and off-road vehicles. It features a multi stranded core and flexible insulation making it ideal for pulling through tight spaces. It is usually rated to 80ºC (176ºF). Although some is also rated to 105ºC (221ºF). It is resistant to oil, chemicals and acids.

“Hook-Up” or “Motor” Wire

The biggest difference between GPT and Motor wire is that motor wire features **finer strands of wire**. This allows it to handle higher voltages.

Motor wire is rated at 600 Volts with a temperature rating of 105ºC (221ºF).

It is resistant to grease, oil, acids, water, solvents, fungus.



SXL Wire

SXL wire has a thick wall cross-linked insulation and is a durable special purpose automotive wire designed for use in engine compartments and other higher temperature applications. SXL wire withstands exposure to temperatures of up to 257°F (125°C). Compared to our standard automotive wire, the polyethylene insulation of our SXL wire has been heat treated creating a cross-linking structure in its molecules. This process produces an tougher insulation with excellent resistance to abrasion, higher temperatures, moisture, oil, grease, gasoline, and other damaging solvents.

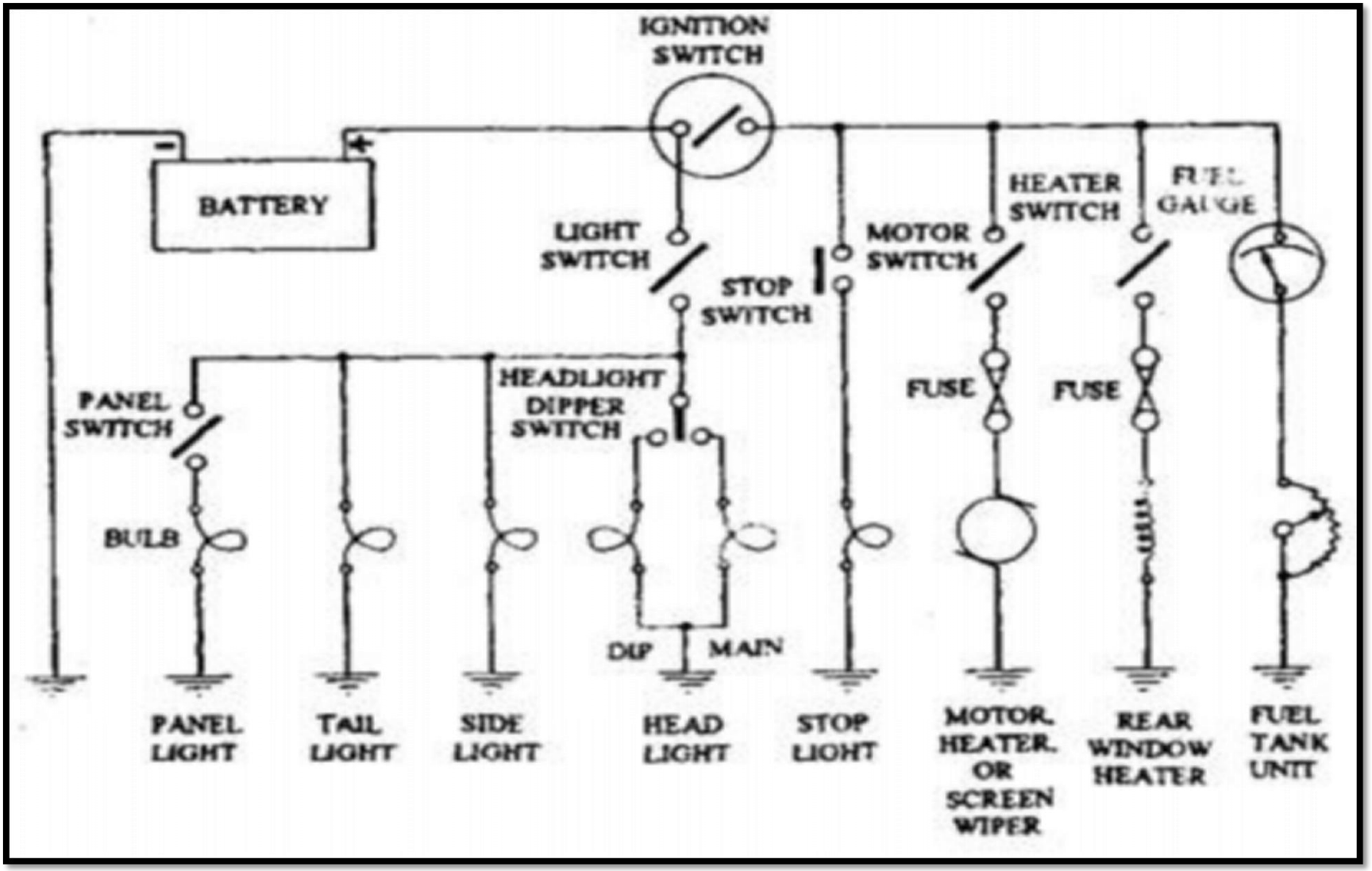
Battery Cable

Battery cable is typically used to connect the battery to the car’s electrical system (typically at the starter) and ground. It is larger gauge, heavier wire. Battery cables are most susceptible to corrosion, and can often be corroded inside the cable where it can’t be seen.

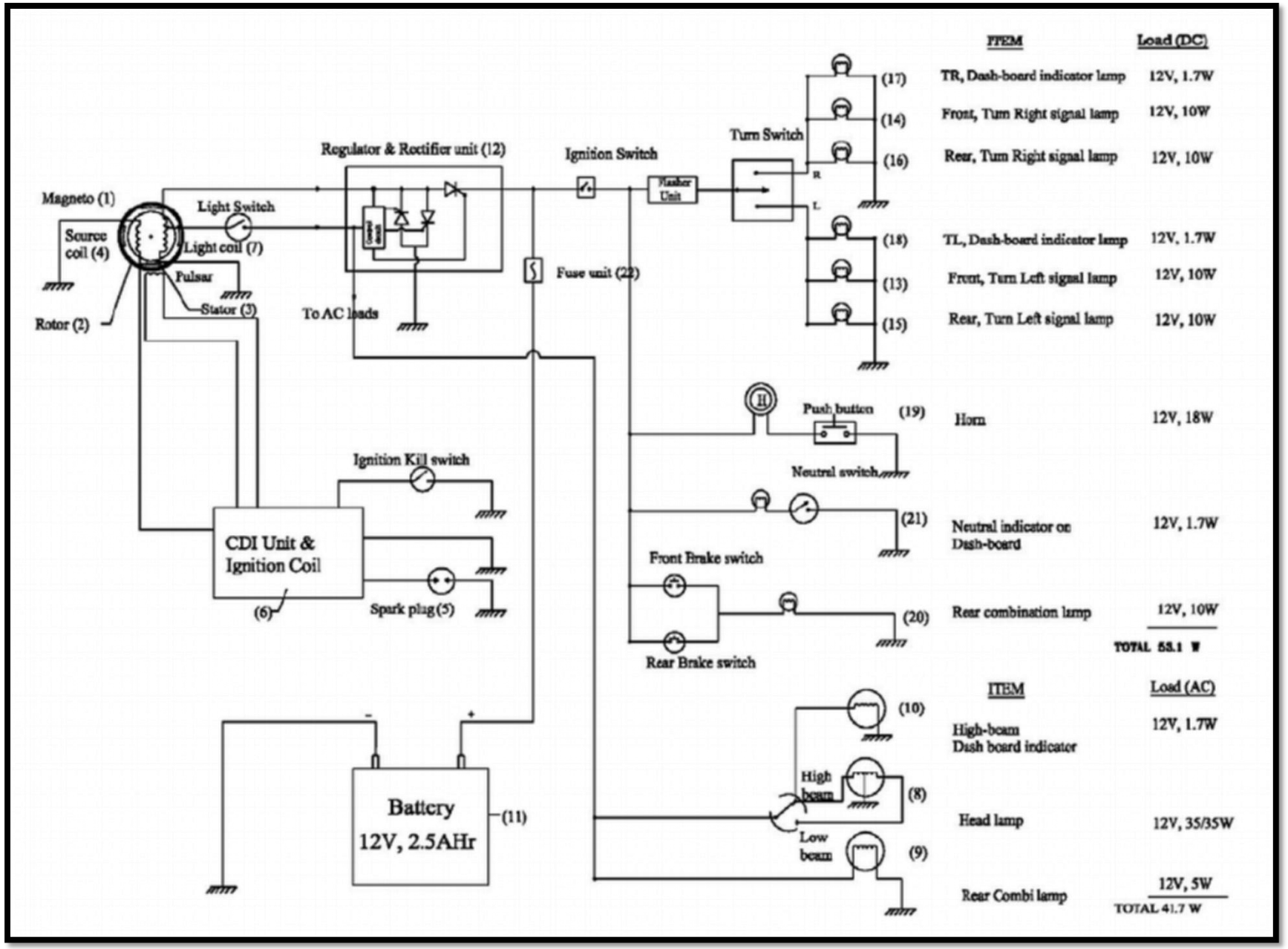
- **types of cables, color codes, cable connectors**
- **fuse system, circuit breakers**
- **Insulation and earth (negative and positive earthing) system**

http://what-when-how.com/automobile/vehicle-circuits-and-systems-automobile/

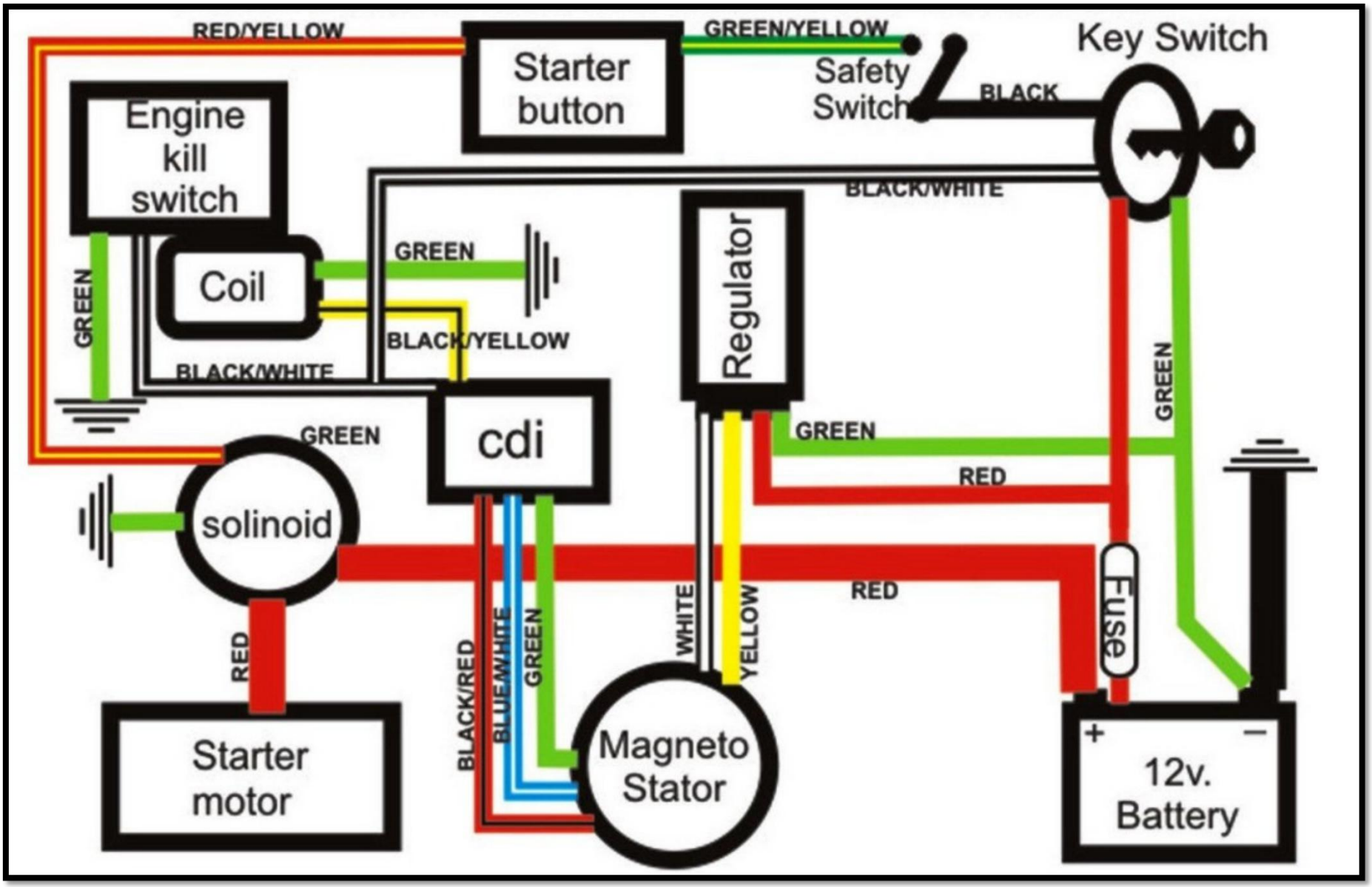
Basic wiring circuit of vehicle

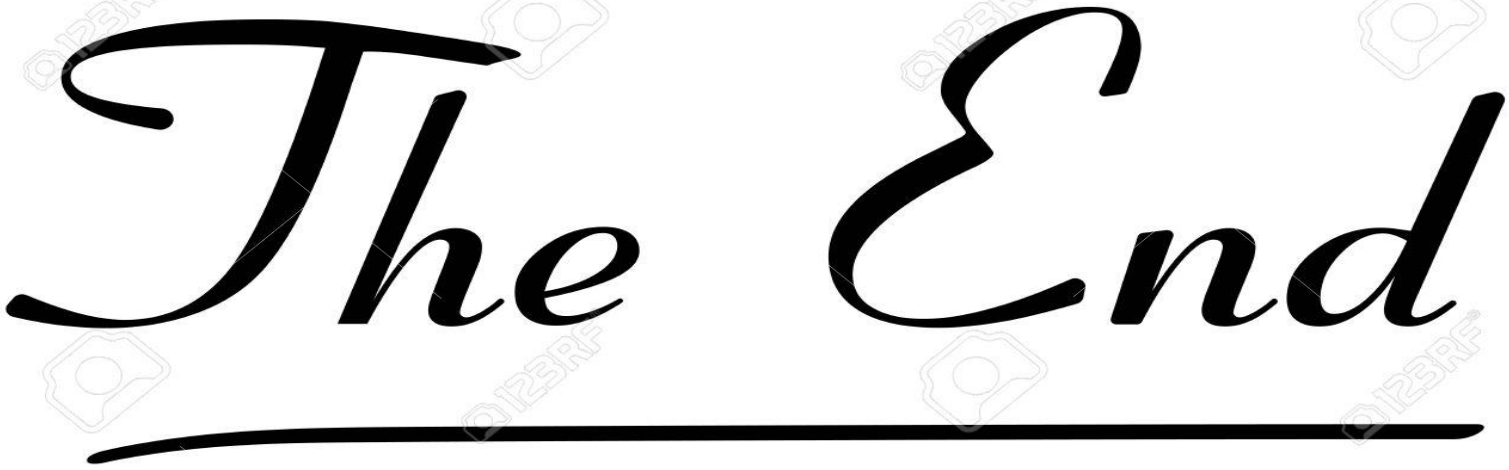


Electrical Circuit Diagram of 2 wheeler



Electrical Circuit Diagram of 4 wheeler




The End

Chapter 2

BATTERY SYSTEM

Battery :

An electrical battery is one or more **electrochemical cells**
that convert stored chemical energy into electrical energy

There are two types of batteries:

primary batteries (disposable batteries), which are designed to be used once and discarded, and

secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times.

Batteries come in many sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centers

Function of Automobile Battery

- Operates the starter motor
- Provides current for the ignition system during cranking
- Supplies power for the lighting systems and electrical accessories when the engine is not operating
- Acts as a voltage stabilizer for the entire electrical system
- Provides current when the electrical demand of the vehicle exceeds the output of the charging system

AUTOMOTIVE BATTERY

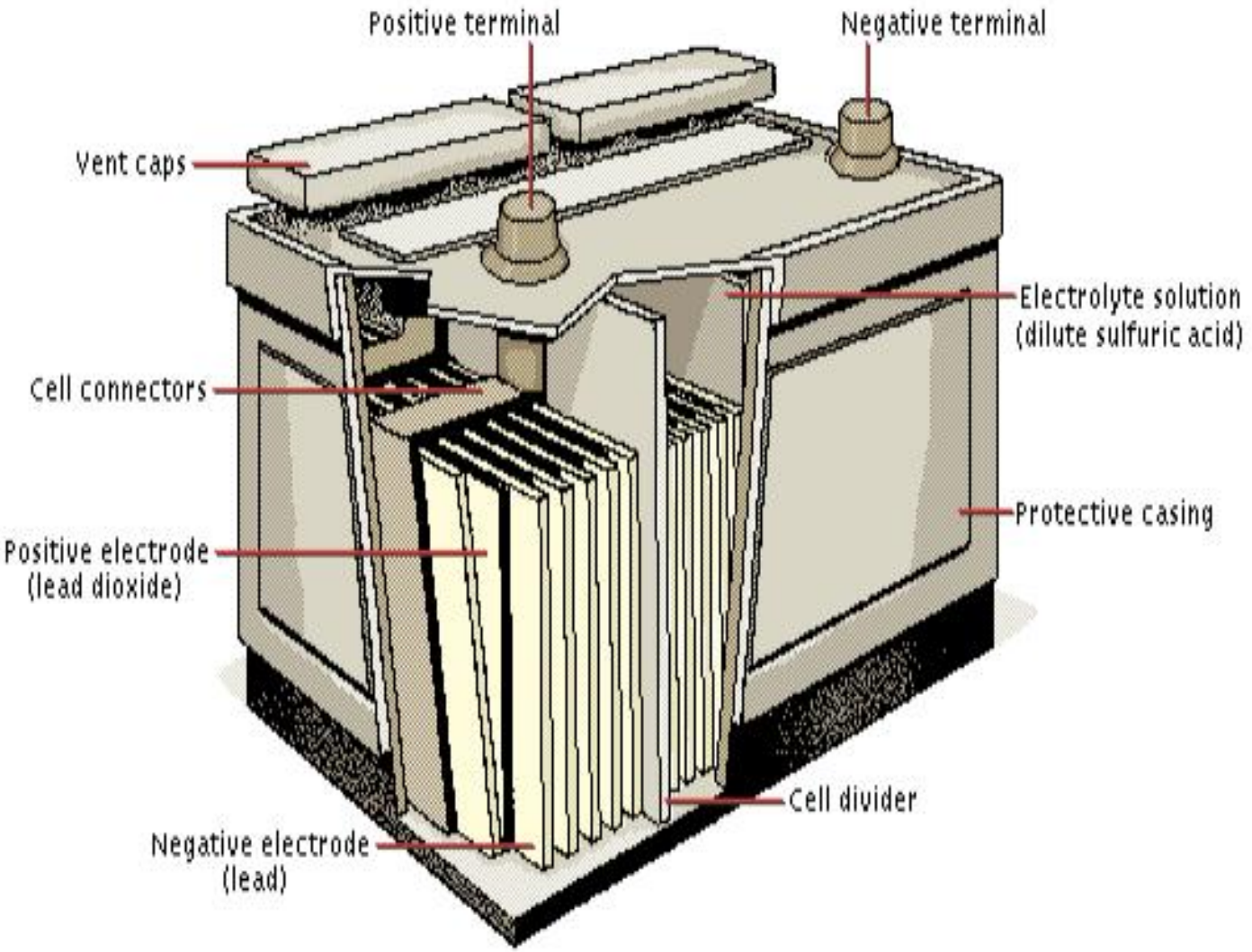
An automotive battery is a type of rechargeable battery that supplies electric energy to an automobile.

Usually this refers to an **SLI** battery **(starting, lighting, ignition**) to power the starter motor, the lights, and the ignition system of a vehicle's engine.

Automotive SLI batteries are usually **lead-acid type or nickel-alkaline type**, and are made of six galvanic cells in series to provide a **12 volt system**. Each cell provides **2.1 volts** for a total of 12.6 volt at full charge.

Heavy vehicles such as highway trucks or tractors, often equipped with diesel engines, may have two batteries in series for a **24 volt system**, or may have parallel strings of batteries.

LEAD ACID BATTERY



CONSTRUCTION

In the battery, several similar plates are properly spaced and welded, or lead-burned, to a strap. This forms a plate group.

Plates of two types are used, one for the positive plate group, the other for the negative plate group. A positive plate group is nested with a negative plate group.

Separators are placed between the plates to **form an element** The separators hold the plates apart so that they do not touch. At the same time the separators are **porous enough to permit liquid** in circulate between the plates.

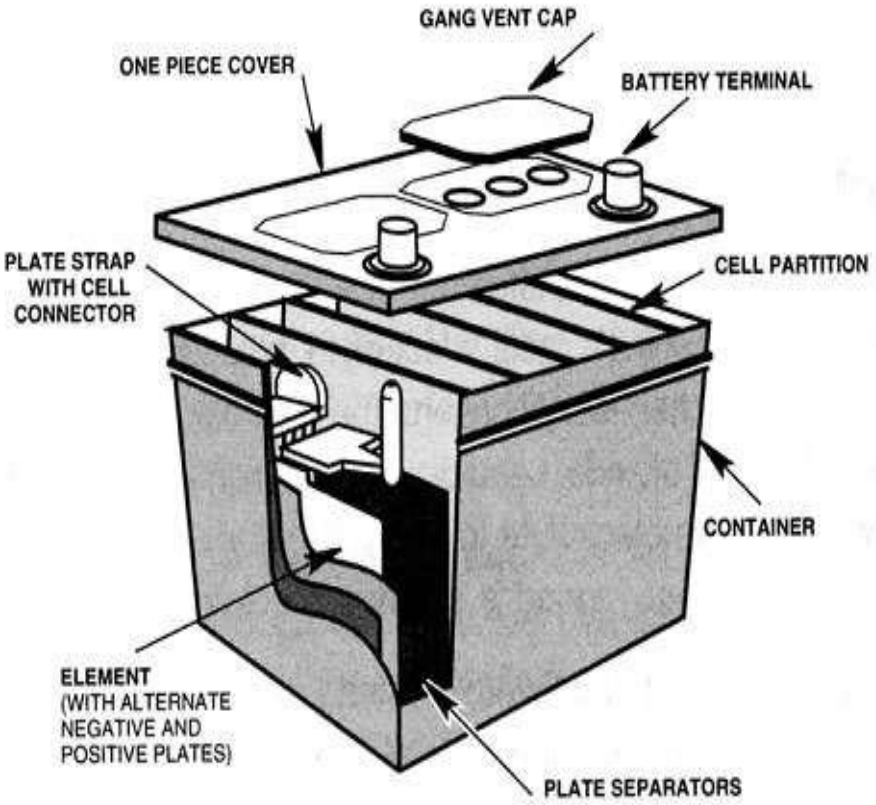
Wooden sheets, spun glass matted into sheets and porous sponge rubber sheets have been used as separators.

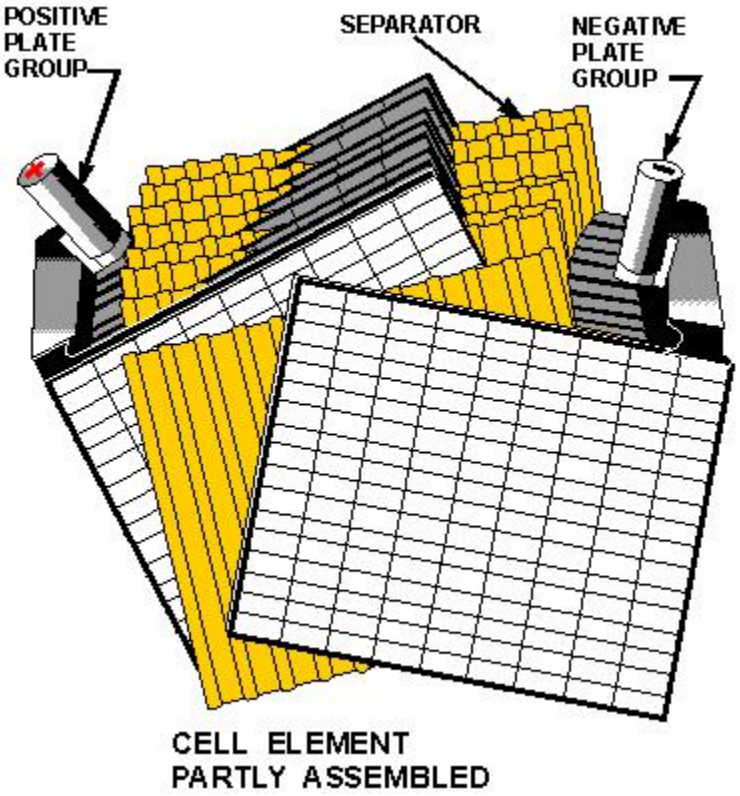
Late model batteries have separators made of acid-resistant polyvinyl chloride on polyethylene saturated cellulose.

An effective separator must possess a number of mechanical properties; such as permeability, porosity, pore size distribution, specific surface area, mechanical design and strength, electrical resistance, ionic conductivity, and chemical compatibility with the electrolyte. In service, the separator must have good resistance to acid and oxidation. The area of the separator must be a little larger than the area of the plates to prevent material shorting between the plates.
The separators must remain stable over the battery's operating temperature range.

In many batteries, the cover has openings through which liquid can be added water; the filler plug or vent caps are removed. After the liquid is added and the battery is given an initial charge. It is ready for operation.
Maintenance-free batteries have no vent caps

Various components in a battery





ELECTROCHEMISTRY

Postive plate: Lead di oxide (PbO_2)

Negative plate: Spongy lead

Electrolyte solution :35% sulfuric acid 65% water

Discharge:

Fully Discharged:

Two identical lead sulfate plates

In the discharged state both the positive and negative plates become lead(II) sulfate ($PbSO_4$) and the electrolyte loses much of its dissolved sulfuric acid and becomes primarily water

Negative plate reaction: $Pb(s) + HSO^-_4(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$

Positive plate reaction: $PbO_2(s) + HSO^-_4(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$

Charging

Fully Charged: Lead and Lead Oxide plates

In the charged state, each cell contains negative plates of elemental lead (Pb) and positive plates of lead(IV) oxide (PbO_2) in an electrolyte of approximately 33.5% v/v (4.2 Molar) sulfuric acid (H_2SO_4). The charging process is driven by the forcible removal of electrons from the negative plate and the forcible introduction of them to the positive plate.

Negative plate reaction:

$PbSO_4(s) + H^+(aq) + 2\text{-}e \rightarrow Pb(s) + HSO^-_4(aq)$

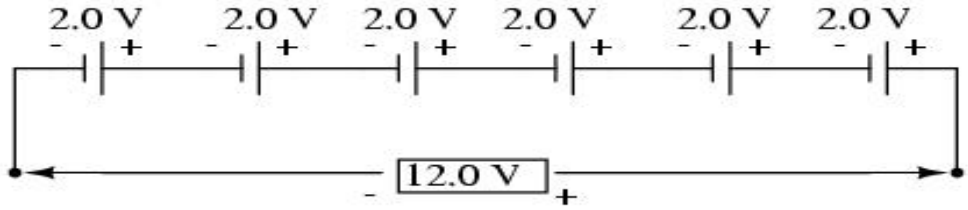
Positive plate reaction:

$PbSO_4(s) + 2H_2O(l) \rightarrow PbO_2(s) + HSO^-_4(aq) + 3H^+(aq) +$
2-e

Adding up of battery voltages

A battery is a cluster of cells connected together for greater voltage and/or current capacity. Cells connected together in series (polarities aiding) results in greater total voltage. Physical cell size impacts cell resistance, which in turn impacts the ability for the cell to supply current to a circuit. Generally, the larger the cell, the less its internal resistance. Cells connected together in parallel results in less total resistance, and potentially greater total current.

The total voltage of a battery is the sum of all cell voltages. A typical automotive lead-acid battery has six cells, for a nominal voltage output of 6 x 2.0 or 12.0 volts:



BATTERY RATINGS

Cranking amperes (CA), also sometimes referred to as marine cranking amperes (MCA), is the amount of current a battery can provide at
32 F (0 C). The rating is defined as the number of amperes a lead-acid battery at that temperature can deliver for 30 seconds and maintain at least
1.2 volts per cell (7.2 volts for a 12 volt battery).

Cold cranking amperes (CCA) is the amount of current a battery can provide at 0 F (−18 C). The rating is defined as the current a lead-acid battery at that temperature can deliver for 30 seconds and maintain at least
1.2 volts per cell (7.2 volts for a 12-volt battery). It is a more demanding
test than those at higher temperatures.

Hot cranking amperes (HCA) is the amount of current a battery can provide at 80 F (26.7 C). The rating is defined as the current a lead-acid battery at that temperature can deliver for 30 seconds and maintain at least
1.2 volts per cell (7.2 volts for a 12-volt battery).

Reserve capacity minutes (RCM), also referred to as reserve capacity (RC), is a battery's ability to sustain a minimum stated electrical load; it is defined as the time (in minutes) that a lead-acid battery at 80 F (27 C) will continuously deliver 25 amperes before its voltage drops below 10.5 volts.

Battery Council International group size (BCI) specifies a battery's physical dimensions, such as length, width, and height. These groups are determined by the Battery Council International organization.

Ampere-hours (A·h) is a measure of electrical charge that a battery can deliver. This quantity is one indicator of the total amount of charge that a battery is able to store and deliver at its rated voltage. Its value is the product of the discharge-current (in amperes), multiplied by the duration (in hours) for which this discharge-current can be sustained by the battery

MAINTENANCE

Fluid level

Car batteries using lead-antimony plates would require regular watering to replace water lost due to electrolysis on each charging cycle. Modern car batteries have reduced maintenance requirements, and may not provide caps for addition of water to the cells.. Prolonged overcharging or charging at excessively high voltage causes some of the water in the electrolyte to be broken up into hydrogen and oxygen gases, which escape from the cells. If the electrolyte liquid level drops too low, the plates are exposed to air, lose capacity, and are damaged. The sulfuric acid in the battery normally does not require replacement since it is not consumed even on overcharging. Impurities or additives in the water will reduce the life and performance of the battery.

Manufacturers usually recommend use of demineralized or distilled water, since even potable tap water can contain high levels of minerals.

CHARGING

In normal automotive service the vehicle's charging system powers the vehicle's electrical systems and restores charge used from the battery during engine cranking. When installing a new battery or recharging a battery that has been accidentally discharged completely, one of several different methods can be used to charge it. The most gentle of these is called trickle charging. Other methods include slow-charging and quick-charging

The voltage regulator of the charge system does not measure the relative currents charging the battery and for powering the car's loads. The charge system essentially provides a fixed voltage of typically 13.8 to 14.4 V (Volt), A discharged battery draws a high charge current of typically 20 to 40 A (Ampere). As the battery gets charged the charge current typically decreases to 2—5 A. A high load results when multiple high-power systems such as ignition, radiator fan, heater blowers, lights and entertainment system are running. In this case, the battery voltage will begin to decrease unless the engine is running at a higher rpm and the alternator/generator is delivering at least enough current to power the load.

In emergencies a vehicle can be jump started by the battery of another vehicle or by a portable battery booster.

Whenever the car's charge system is inadequate to fully charge the battery, a battery charger can be used. Simple chargers do not regulate the charge current, and the user needs to stop the process or lower the charge current to prevent excessive gassing of the battery. More elaborate chargers, in particular those implementing the 3-step charge profile, also referred to as IUoU, charge the battery fully and safely in a short time without requiring user intervention.

Desulfating chargers are also commercially available for charging all types of lead-acid batteries.

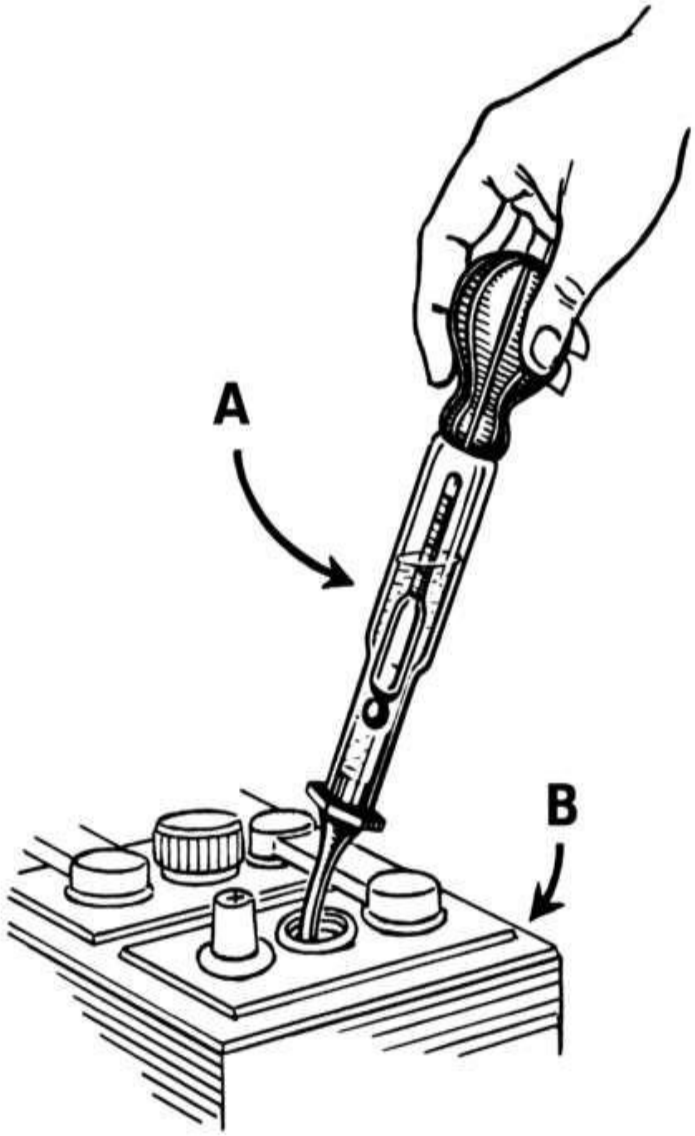
BATTERY BEING JUMP STARTED

Storage

Batteries last longer when stored in a charged state. Leaving an automotive battery discharged will shorten its life, or make it unusable if left for a long time (usually several years); sulfation eventually becomes irreversible by normal charging. Batteries in storage may be monitored and periodically charged, or attached to a "float" charger to retain their capacity. Batteries are prepared for storage by charging and cleaning deposits from the posts. Batteries are stored in a cool, dry environment for best results since high temperatures increase the self discharge rate and plate corrosion.

MEASUREMENT OF CHARGE

Because the electrolyte takes part in the charge-discharge reaction, this battery has one major advantage over other chemistries. It is relatively simple to determine the state of charge by merely measuring the specific gravity (S.G.) of the electrolyte**, It is the weight of the sulfuric acid-water mixture compared to an equal volume of water.** the S.G. falling as the battery discharges. Some battery designs include a simple hydrometer using colored floating balls of differing density. When used in diesel-electric submarines, the S.G. was regularly measured and written on a blackboard in the control room to indicate how much longer the boat could remain submerged



Open circuite voltage for various charges

The open circuit voltage , is measured when the engine is off and no loads are connected. It can be approximately related to the charge of the battery

Open circuit voltage		Approximate charge	Relative acid density
12 V	6 V		
12.60 V	6.32 V	100%	1.265 g/cm^3
12.35 V	6.22 V	75%	1.225 g/cm^3
12.10 V	6.12 V	50%	1.190 g/cm^3
11.95 V	6.03 V	25%	1.155 g/cm^3
11.70 V	6.00 V	0%	1.120 g/cm^3

Reasons for battery failure

Common battery faults include:

- Shorted cell due to failure of the separator between the positive and negative plates
- Shorted cell or cells due to build up of shed plate material below the plates of the cell
- Broken internal connections due to corrosion
- Broken plates due to vibration and corrosion
- Low electrolyte level
- Cracked or broken case
- Broken terminals
- Sulfation after prolonged disuse in a low or zero charged state

Casestudy

delco

IDNS40 BATTERY USED IN MARUTI 800 AND OMNI

Old JIS Battery Type	New ACDelco Part Number	Capacity (AH)		CCA	RC	Max Overall dimensions (mm)			Approx. Weight (Kg)		Application
		5 Hr. Rate	20 Hr. Rate	(Amps)18° C	(Min.)25° C	L	W	H	Dry	Filled	
NS40	IDNS40	26	32	225	45	197	129	227	7.0	10.0	Maruti-800, Maruti Omni, Maruti 800 DX

Plate Details	IDNS40
Positive Plates	24
Negative Plates	30

Delco IDN150 BATTERY USED IN TATA HCVS

Old JIS Battery Type	New ACDelco Part Number	Capacity (AH)		CCA	RC	Max Overall dimensions (mm)			Approx. Weight (Kg)		Application
		5 Hr. Rate	20 Hr. Rate	(Amps)18° C	(Min.)25° C	L	W	H	Dry	Filled	
N150	IDN150	120	150	690	294	508	220	213			TATA HCV, Ashok Leyland Dumpers, Escort JCB Loaders, Fork Lifts, Inverter Application (-— KVA)

Plate Details	IDN150
Positive Plates	72
Negative Plates	78

ELECTRIC VEHICLE BATTERY

An electric vehicle battery (EVB) or traction battery is a rechargeable battery used for propulsion of battery electric vehicles (BEVs). Traction batteries are used in forklifts, electric Golf carts,, and other electric vehicles.

They are designed to give power over sustained periods of time

Batteries for electric vehicles are characterized by their relatively high power-to-weight ratio, energy to weight ratio and energy density; smaller, lighter batteries reduce the weight of the vehicle and improve its performance. Compared to liquid fuels, all current battery technologies have much lower specific energy; and this often impacts the maximum all-electric range of the vehicles over sustained periods of time

Types of batterys used in electric vehicles

- Lead-acid
- Nickel metal hydride
- Zebra
- Lithium ion

Lead-acid batteries are the most available and inexpensive. Such conversions generally have a range of 30 to 80 km
Production EVs with lead-acid batteries are capable of up to 130 km (80 mi) per charge.
NiMH batteries have higher energy density than lead-acid; prototype EVs deliver up to 200 km (120 mi) of range.
New lithium-ion battery-equipped EVs provide 320–480 km (200–300 mi) of range per charge. Lithium is also less expensive than nickel.
Nickel-zinc battery are cheaper and lighter than Nickel-cadmium batteries. They are also cheaper but heavier than Lithium-Ion batteries

high power Ni-MH Battery of Toyota NHW20 Prius, Japan

Nissan Leaf's lithium-ion battery pack.

THANK YOU