ductors are used to enable the circuit to be completed, i.e., feed wire, switch wire and return wire. In vehicles, the metal chassis is used for return wire (ground return), in some case the switch is incorporated in the unit. In some units, the switch is placed in the return side of the unit instead of on the feed side. Certain accessory circuits are fed through the ignition switch and certain auxiliary lighting circuits through the side and tail lamp switch.

Main feed colour

There are seven main feed colours, each of which is allocated to a particular circuit. Feed wires are braided in the main circuit colour, switch wires are braided in the main colour but carry also a coloured tracer woven spirally into the braiding, return or ground leads are black.

1 **Brown -** Battery circuit interior light, horn, control box, ammeter, ignition switch.
2 **Yellow -** Generator circuit - generator terminals to control box terminals and ignition warning light.
3 **White -** Ignition circuit - all units which are wired through the ignition switch and which are essential for the starting and running of the vehicle and which are not fused, i.e., electric control pump, starting motor, solenoid switch, etc.
4 **Green -** Fused auxiliary circuits which are feed through the ignition switch, i.e., stop lamps, fuse gauge, direction indicators, windshield wiper, etc.
5 **Light green -** Flasher unit to flasher indicator waving light.
6 **Blue -** Headlamp circuit fed from terminal on lighting switch. Included in this circuit are fog lamps, panel lights, door lights, etc., which are only required when the side lamps are switched on.
7 **Black -** All ground wired. If a unit do not internally grounded or is mounted on an insulated portion of the vehicle, a cable must be connected from the body of the unit to a good ground point on the chassis.

Cable sizes

Cable size are indicated by the number of strands of wire followed by the diameter of each strand measured in thousands of an inch, e.g. 14/0.12, i.e., fourteen strands of twelve thou' wire (30 SWG)

On 12 volt systems, as generally used on the vehicles, the current carrying capacity of cables having copper conductors can be reckoned as follows

Cable size	Current carrying capacity (amps.)
44/0.012	22
28/0.012	14
14/0.012	7

The following cable sizes should generally be used when rewiring the vehicle

Main battery feed circuit	44/0.012
Main charging circuit	28/0.012
Field circuit	14/0.012
Ignition circuit	14/0.012
Accessories	14/0.012
Side and tail lamps	14/0.012
Head lamps	28/0.012

Circuit tracing

The tracing or checking of the car wiring system is considerably simplified if the principle of feed wire, switch wire and return wire is considerably accepted. The feed wire must be interpreted as being from the extreme limit of the run, i.e., from the terminal post of the battery to its destination on the switch or control. A feed wire can comprise two or three distinct sections of various size cables and each section can be utilised as a section of more than one independent feed.

For switch wire circuits, a similar layout is adopted which would start from the appropriate lighting switch terminal to a junction box or multiple snap connector, following through the destination via a joint at a further snap connector and finally coupled to the lamp unit by a further feed wire.

The return circuit is mainly by way of the vehicle chassis and is coupled to the battery terminal post by means of a short length of heavy starter size cable or heavy flexible woven copper braid.

Electrical continuity must be maintained correctly. A suitable sized bonding or ground coupling must be used where electrical coupling is likely to be impaired by resistance or intermittent contacting. Usually, the switch is placed on the insulted side of the circuit but sometimes it is inserted on the ground side of the unit as with the steering - column horn switch which is coupled direct to the horn or through the horn relay. Bu adopting these methods, considerable length of cable is saved and more compact wiring is done.

Battery

Objectives: At the end of this lesson you shall be able to

- **state classification of cells**
- **explain the construction of a lead acid battery**
- **explain the chemical action during discharging**
- **explain the chemical action during charging**
- **explain maintenance of a battery**
- **explain testing of a battery**
- **explain battery selection and rating**
- **explain battery charging method**
- **explain advantages of maintenance free battery.**

A cell is an electrochemical device consisting of two electrodes and an electrolyte. The chemical reaction between the electrodes and the electrolyte produces a voltage.

Cells are classified as:

– dry cells

– wet cells

Dry cells : A dry cell has paste or gel electrolyte. It is semi-sealed and could be used in any position.

Wet cells : It consists of two plates and a liquid electrolyte. These cells have vent holes to allow the gases to escape during charging and discharging. The most common wet cell is the lead acid cell; wet cells can be recharged for reuse.

Primary cells : Primary cells are those cells which are not rechargeable. Chemical reaction that occurs during discharge is not reversible. The following types of primary cells are used.

– Voltaic cell

– Carbon zinc cell

– Alkaline cell

– Mercury cell

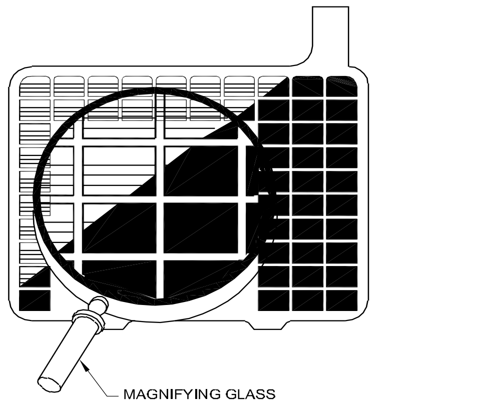
– Silver oxide cell

– Lithium cell.

Secondary cell (Lead acid battery) : These cells can be recharged by supplying electric current in the reverse direction to that of a discharged battery.

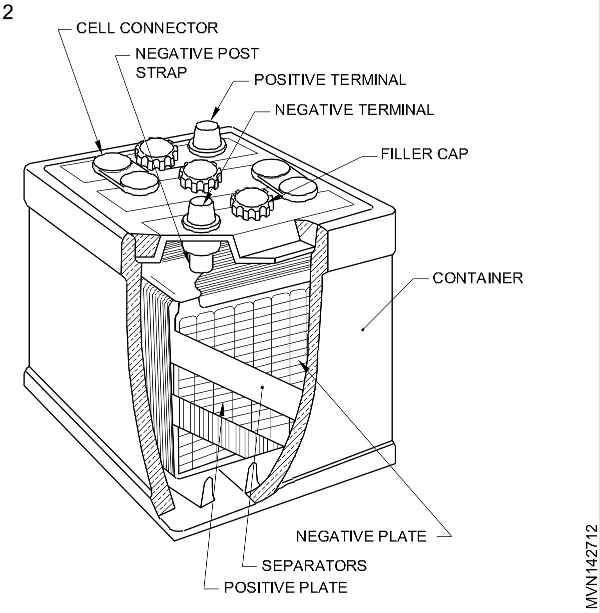
Lead acid battery (Figs1&2)**:** This battery is an electrochemical device for converting electrical energy into chemical energy and vice versa. The main purpose of the battery is to store electrical energy in the form of chemical energy. It provides supply of current for operating various electrical accessories, when the engine is not running. When the engine is running it gets electric supply from the dynamo/alternator. It is also known as accumulator and storage battery.

Fig 1



Construction: The automobile battery's plates are rectangular. They are made of lead. Antimony alloy is used to provide them strength.

Fig 2



The group of plates, which are connected to the positive terminal of the cell, consists of grids filled with a paste of lead peroxide. This lead is brown in colour. The group of plates, which are connected to the negative terminal of the cell, consists of grids filled with metalic lead which is spongy in nature. This lead is dull grey in colour.

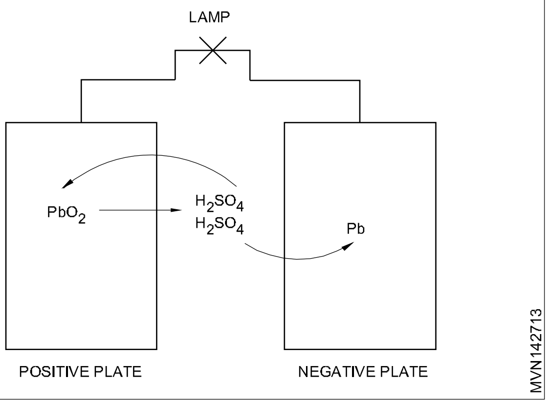
Each a group of plates is held together by a post strap, to which individual plates are welded. The post strap is extended up to the cell cover to provide battery terminals. The positive and negative plates are arranged alterna-tively, and in between the plates, seperators are used to prevent contact of the positive and negative plates. Separators are made of specially treated wood, hard rubber, resin, integrated fibre or in combination with rubber or mats of glass fibres. The container in which the plates are placed is made of hard rubber which is not affected by the electrolyte. A solution of sulphuric acid and distilled water is added until the level of the liquid in the container is about 1/4" to 3/8" above the top of the plates. A filler cap with air vents is provided to allow gases to escape out.

Chemical Reactions

Discharging (Fig.3)**:** During discharging, the sulphuric acid is broken into two parts, hydrogen (H_2) and sulphate (SO_4). The hydrogen is liberated at the lead peroxide plates (PbO_2) reducing them to lead oxide (PbO) which combines with parts of the sulphuric acid to form lead sulphate ($PbSO_4$) and water (H_2O). The SO_4 is liberated at the spongy lead plate (Pb) and combines with them to form lead sulphate ($PbSO_4$). During this process the electrolyte becomes less concentrated due to absorption of the sulphate by the lead plates.

$$\underset{(+ve)}{PbO_2} + \underset{(electrolyte)}{2H_2SO_4} + \underset{(-ve)}{Pb} \rightleftharpoons \underset{(+ve)}{PbSO_4} + \underset{(water)}{2H_2O} + \underset{(-ve)}{PbsO_4}$$

Fig 3

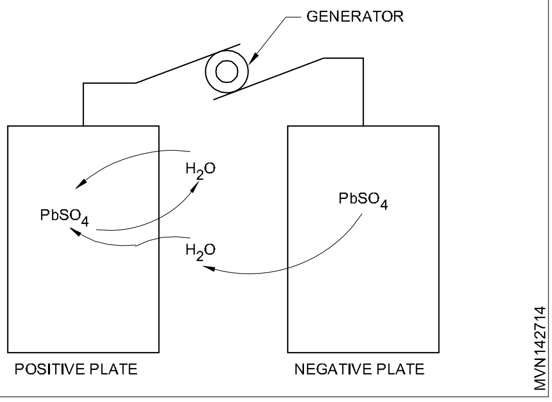


Charging (Fig.4)

When the battery is charged by passing current through a dynamo or charger in the opposite direction, the reverse chemical reaction takes place. The lead sulphate on one plate becomes lead peroxide (+ve plate). The lead sulphate on the other plate (-ve plate) becomes spongy lead and the electrolyte becomes more concentrated because of the increased amount of sulphuric acid.

$$\underset{(+ve)}{PbSO_4} + \underset{(water)}{2H_2O} + \underset{(-ve)}{PbSO_4} \rightleftharpoons \underset{(+ve)}{PbO_2} + \underset{(Electrolyte)}{2H_2SO4} + \underset{(-ve)}{Pb}$$

Fig 4



Maintenance of battery: Batteries are expensive items to replace. They should be serviced regularly as recommended by the manufacturer. If maintained properly, they can be used for longer periods. The following aspects are to be checked to maintain the battery in good condition.

Check and top up electrolyte level every week. Electrolyte should be 10 mm to 15 mm above the plates.

Check the specific gravity of the battery with a hydrometer. (Fig 5) If the specific gravity falls below 1.180 then add a few drops of sulphuric acid.

Sp. gravity readings and the state of charge of the battery are as follows.

Sl.No.	Specific	State of charge of the battery
1	1.260 - 1.280	Fully charged
2	1.230 - 1.260	3/4 charged
3	1.200 - 1.230	1/2 charged
4	1.170 - 1.200	1/4 charged
5	1.140 - 1.170	About run down
6	1.110 - 1.140	Discharged

Check the voltage across the cell terminals of each cell by using a cell tester. Cell voltage is 2 to 2.3 volts per cell for fully charged condition.

If the voltage of each cell is less than specified, then the battery should be recharged.

While charging do not overcharge the battery.

Keep the battery terminals always tight and clean.

To prevent formation of corrosion on the terminals smear petroleum jelly on it.

Voltage check of battery: With the help of a voltmeter the voltage of battery is tested. This will commonly vary from 12-13V

Battery selection (Fig 6)**:** Most cars in current production are equipped with a 12V battery. When a manufacturer

Fig 5

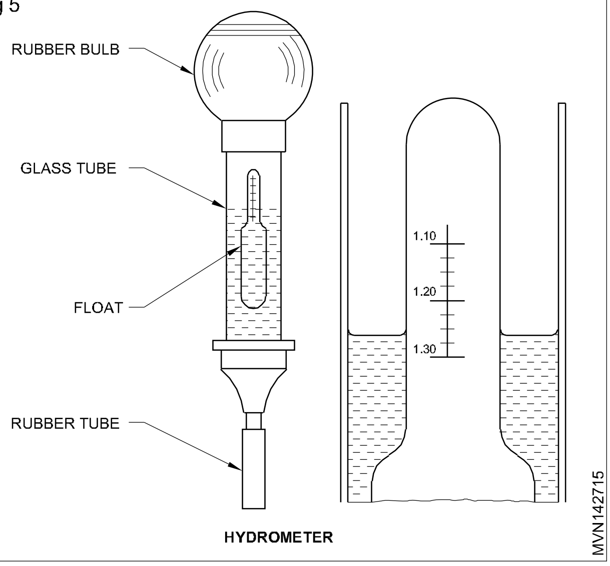
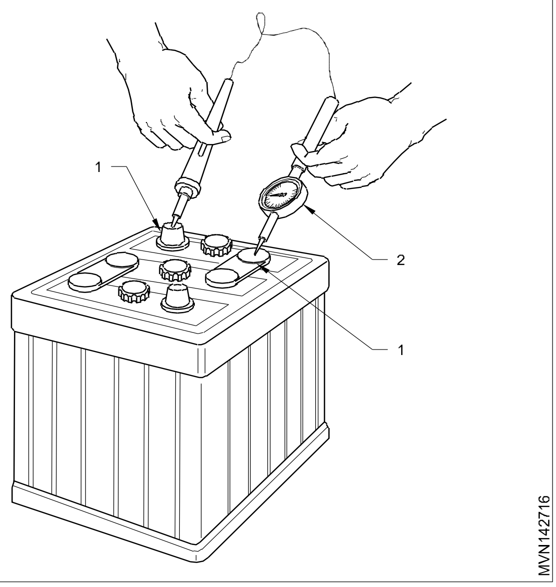


Fig 6



installs a battery in a new car that battery is chosen to meet the requirements of that particular car. Prime importance is the battery's ability to crank and start the engine. The current required to crank on engine can range from 150A to over 500A depending on the size of the engine, the temperature and the viscosity of the oil in the engine. Those factors are all considered in battery selection. The number and type of electrical options installed in the car are also considered.

The lead acid batteries are made for different vehicle application to suit the electrical demands, while the voltage of the battery remains same for all application, the ampere-hour rate changes as per demand.

The following examples reveal the importance of ampere-hour of a battery.

Vehicle type	Battery applicable
2.5 Amps 12V	Two wheeler without starter
7 Amps 12V	Two wheeler with starter motor
35 Amps 12V	800CC - 1000 car petrol
40 - 45 Amps 12V	1300 Diesel vehicles
60 Amps 12V	2.5 Lit LCV
80 Amps 12V	4 Lit medium
120 Amps 12V	6 Lit Diesel HCV
180 Amps 12V	6 Lit Diesel passenger

Battery rating

Ampere-hour rating: The ampere-hour rating provides a measure of how much current a battery at 80^{0}F (27^{0}C) will deliver for a fixed period of time without the cell voltage dropping below 1.75V (10.5 total terminal volts). Due to a specified 20 hour time period, this test is sometimes referred to as the "20 hour test". The rating number is determined by multiplying the current delivered by 20. If a battery can deliver 3A for the 20 hour period, it receives a 60 ampere-hour rating. If a battery can deliver 5A for the 20 hour period, it receives a rating of 100 ampere-hour.

CONVENTIONAL BATTERIES

BATTERY CAPACITY (AMPERE HOURS)	DISCHARGE RATE (AMPERES)
36	155
41	145
45	190
53	175
54	225
68	220
77	228

MAINTENANCE-FREE BATTERIES

BATTERY CAPACITY (AMPERE HOURS)	DISCHARGE RATE (AMPERES)
53	200
63	215
68	235

Battery charging: A discharged battery in good condition can be charged and retuned to service.

Many types of battery in use, but all chargers operate on the same principle. They apply an electrical pressure that forces current through the battery to reverse the electro chemical action in the cells.

Charging rates: The amount of charge a battery receives is equal to the rate of charge, in amperes, multiplied by the amount of time, in hours, that the charge is applied. As an example, a battery charged at the rate of 5A for a period of 5 hours would receive a 25 ampere-hour charge. To bring a battery to a fully charged condition.

Initial rate for constant voltage taper rate charger.

To avoid damage, charging rate must be reduced or temporarily halted if:

1 Electrolyte temperature exceeds 125^{o}F.

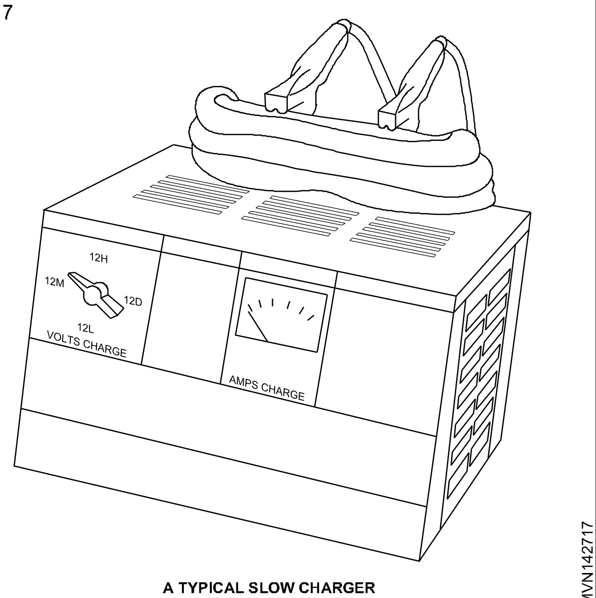
2 Violent gassing or spewing of electrolyte occurs.

Battery is fully charged when over a two hour period at a low charging rate in amperes all cells are gassing freely and no change in specific gravity occurs. For the most satisfactory charging, the lower charging rates in amperes are recommended.

Full charge specific gravity is 1.260 - 1.280 corrected for temperature with electrolyte level at split ring.

Slow charging (Fig 7)**:** Slow charging consists of charging a battery at a rate of about 5A for a time sufficient to bring the specific gravity of the electrolyte to its highest reading. Slow charging many require from 12 to 24 hours of time. A battery that is sulphated may require even more time. During the charging period, the electrolyte temperature should not exceed 110^{0}F (43^{0}C). If the electrolyte temperature rises above 110^{0}F (43^{0}C), the charging rate should be decreased.

Fig 7



A TYPICAL SLOW CHARGER

A conventional battery with vent plugs is considered fully charged when the electrolyte is gassing freely and when no further rise in the specific gravity is noted at intervals of 1 hours. A sealed battery should be slow charged until the green dot appears in the built-in hydrometer. In some instances, a sealed battery must be slightly shaken to allow the green dot to appear.

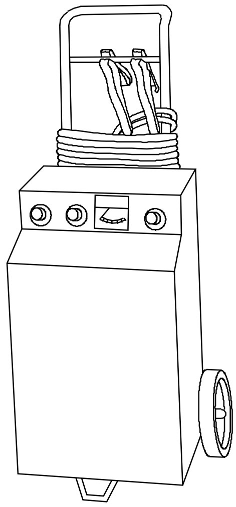
Fast charging (Fig 8)**:** Fast charging will not fully recharge a battery, it will restore the charge sufficiently to allow the battery to be used.

Fast charging consists of charging a battery at a rate from 10 to 50A. The exact charging rate depends on the construction of the battery, the condition of the battery and the time available. The temperature of the electrolyte provides an indication of the current charging rate. If the electrolyte temperature rises above 125^0F (65^0C), the charging rate is too high and should be reduced. Since a high charging rate and the resultant high temperature can damage a battery, a battery should be charged at the lowest possible rate.

Features of sealed maintenance free battery

- No need for checking electrolyte level and tapping throughtout the life.
- Seal construction ensures no leakage of electrolyte from terminal or casing.

Fig 8



A TYPICAL FAST CHARGER

Benefits

- Saving of 100 litres of distilled water through out its life time as compared to convention batteries.
- Saving of man power for regular topping up & cleaning corroded terminals as in conventional batteries.
- No damage of flooring by spoilage of batteries acid or water during maintenance.
- No need of separate battery room.

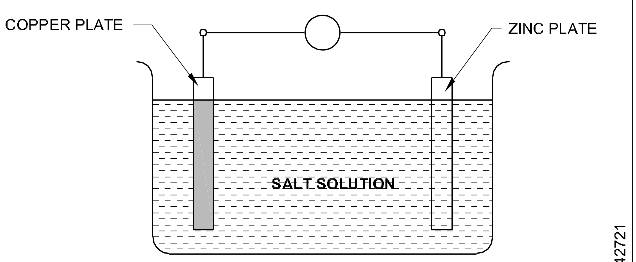
Electricity effects

Objectives: At the end of this lesson you shall be able to
- **state electro chemical process**
- **state the effect of an electric currents.**
- **state thermo couple**
- **state thermo electric energy**
- **state piezo electric energy.**

Chemical sources (Electro chemical process) (Fig 1)

If two electrically conducting materials (metals) are immersed in salt solutions, an electric charge is produced between the two metals (electrodes, poles). Two examples are given below.

Fig 1



ELECTRICITY GENERATION BY DISSOLVING IN ELECTROLYTES

Copper and Zinc in salt solution is one combination

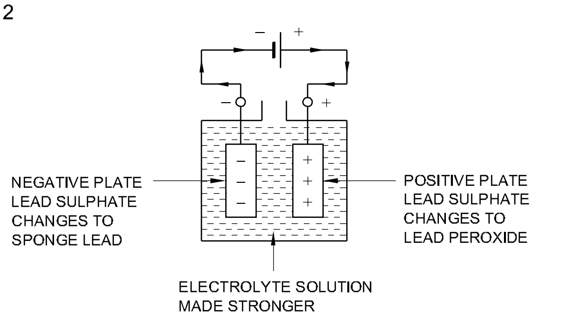
Lead and sulphuric acid is another combination.

This arrangement is known as wet cell and gives direct current. The second combination is used in a Lead Acid Battery for Motor vehicles.

Dynamic electricity (Fig 2)

The current is produced by A/C or D/C generators, by conversion of mechanical energy into electrical energy. The generation of electric current is based on the fact when a conductor is moved in a magnetic field an E.M.F is set up in the conductor. When a large number of conductors are moved in a powerful magnetic field, high voltages and current are produced. This is the Principle of Dynamo.

Fig 2



DURING CHARGING PROCESS