Introduction: The battery is an electro-chemical device for converting electrical energy into chemical energy. The main purpose of the battery is:-

- ✓ To store electrical energy
- ✓ To provide a supply of current for operating the cranking motor
- ✓ To provide a supply of current to other electrical units when the engine is not running.
- ✓ To assist the generator when it is not able to cope up with full load demands.

The construction of automobile batteries is such that they are in a position to

- ✓ Withstand vibrations
- ✓ Withstand high rates of charging and discharging currents commonly associated with automobile service.

Two principle types of batteries are used in automobiles: lead acid batteries and nickel alkaline batteries. The lead acid batteries were being used more extensively but are being increasingly replaced by nickel alkaline batteries in commercial vehicles and motor cycles.

Principle of Battery Operation: The battery operates on the principle of electrolysis. Water on adding even a trace of sulphuric acid becomes conducting in nature. Now if an electric current is passed through it, it can be easily split up into hydrogen and oxygen. During electrolysis, the ions are liberated at the electrodes with the help of which the current enters and leaves the electrolyte. These ions are called carriers of electric charge. When these ions reach the electrodes they give up their charges. The positive and negative electrodes of a lead acid battery are immersed in dilute sulphuric acid. When the battery is fully charged, there is lead peroxide on the positive plate and spongy lead on the negative plate as active materials. During discharging, the chemical reactions forms lead sulphate on both the plates thereby liberating water thereby lowering the specific gravity of electrolyte. During charging there is reversal of this chemical reaction which increases the specific gravity of electrolyte. The chemical reactions that take place during charging and discharging are as follows:

	Charged				Discharged	
Positive Plate	Electrolyte	Negative Plate		Positive Plate	Electrolyte	Negative Plate
PbO_2	+ $2H_2SO_4$	+ Pb	=	$PbSO_4$	+ 2 H_20	+ $PbSO_4$
Lead peroxide	Sulphuric acid	Spongy lead		Lead sulphate	Water	Lead sulphate

Depending on their chemical constitution the ions on reaching the electrodes may have chemical reaction with them. A back emf is set up in the opposite direction to that of applied voltage due to the absorption of the negative and positive charges by the positive and negative terminals.

If the battery terminals are connected to the external circuit after disconnecting the charging current, there will be a flow of current in the reverse direction through the electrolyte to that of the charging current because of back emf. The back emf reduces with the continuation of discharge depending upon the rate and the time of discharge.

The fig. 1 shows the typical voltage curves for a lead acid battery.

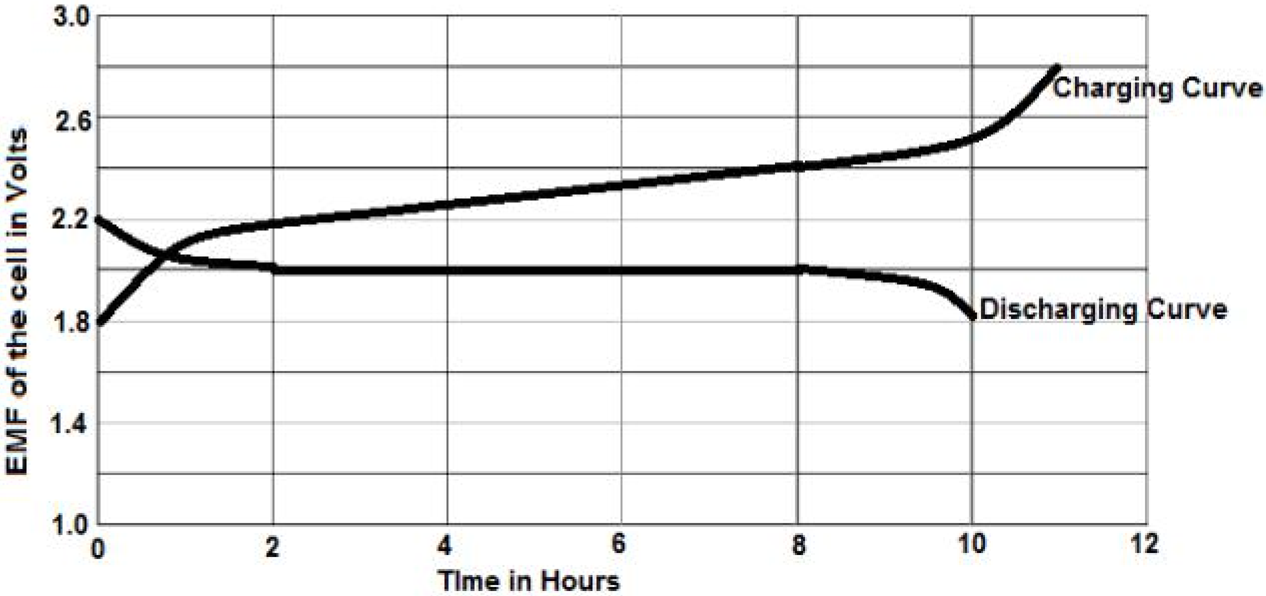


Fig.1 Voltage curve for lead acid battery

At first the voltage per cell rises rapidly and then there is gradual rise afterwards. The voltage rises more rapidly towards the end of the charge. During discharging the cell voltage drops to about 2.2 volts on open circuit and then rapidly falls to 2 volts during initial period of discharge. After this it fairly remains constant until towards the end of the discharge when a sudden fall in voltage takes place. At this stage the battery should not be discharged any more instead should be further recharged otherwise it will cause excessive plate sulphation resulting in permanent damage of the plates.

Battery Voltage: A 6 V battery consists of three cells of 2 V each and a 12 V battery consists of six cells of 2 V each. The cells are all similar in internal construction and operation.

Battery Construction : In case of a lead acid battery the following are the main parts from the construction point of view:

1. Plates
2. Separator
3. Group
4. Element
5. Container
6. Electrolyte
7. Cell Connectors
8. Vent Plug

1. **Plates:** The plates are a rectangular lattice like grid in case of an automobile battery. They are moulded from lead-antimony alloy. The active material is held in place by the horizontal and vertical bars of the grid. These bars further help in distributing the current evenly over the plate.

   The fig. 2 shows the battery grid. It should be designed in such a manner that it must hold the active material in position as well as it should provide a large surface area to the electrolyte. The active material must be in close contact with the grid frame for good conductivity.

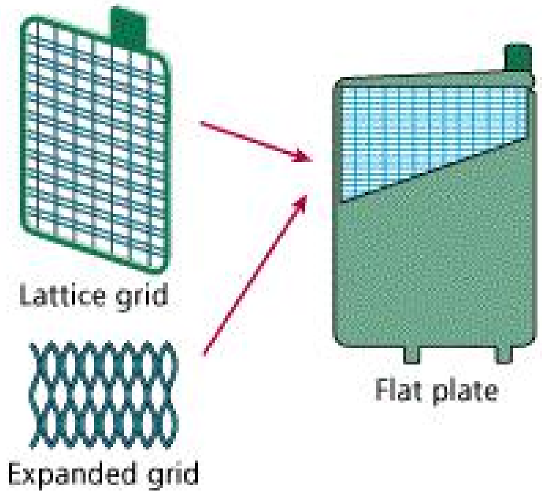


Fig.2 Battery plate grid

Exide batteries manufactured in India have a special grid design. It incorporates wires of triangular section which are arranged alternately geometrically so that the active material is locked firmly into place and does not shed. This helps in maintaining an optimum balance between grid metal thickness and active material quantity in each plate thus giving outstanding power and life. Similarly Chloride developed a grid alloy which by addition of small quantities of special alloying elements resulted in increase of the positive plate life, resistance to overcharge and grid corrosion. This alloy is also resistant to the steady attack on grids which occurs when a battery is lying idle.

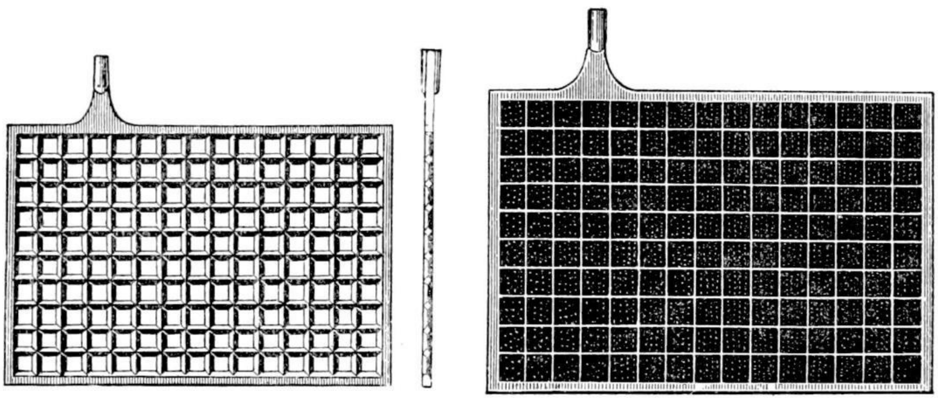


Fig. 3 Battery plate with lead0oxide paste

The fig.3 shows the battery plate with active material applied to it and ready to be attached to the plate strap. In case of Exide batteries, both negative and positive plates are reinforced with fibre to make them withstand bumps, vibrations and shocks of bad road conditions without shedding which happens in the case of ordinary plates.

2. **Separator:** In case of automobile battery a limit is imposed on the size of the battery due to which a small clearance is kept between the negative and positive plates. In order to prevent the positive and negative plates from actually touching, separators are used in between these plates. The separators may be made of micro-porous rubber, non-conducting ebonite, glassmat or wood such as Port Orford cedar. Exide batteries manufactured in India make use of PORVIC microporous PVC separators.

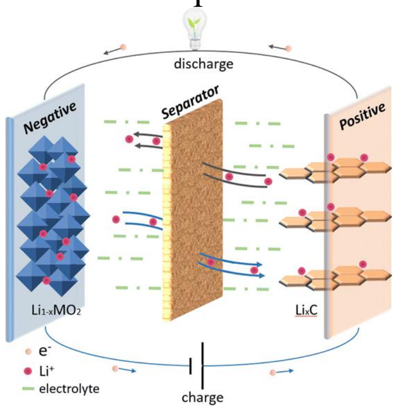


Fig. 4 Separator

The separators in a battery have to carry out a number of functions. They have to keep the plates apart so that there can be no electrical contact between positive and negative plates except through the acid. At the same time they have to act as a porous reservoir for acid with as many minute acid paths as possible traversing their thickness so that they can carry the heavy starting currents without undue resistance, which would waste power uselessly in heating the battery. Then they must be mechanically strong and resilient, and they must not lose their strength or become eroded in service although they are continually immersed in strong acid and subjected to intense oxidation during the charging of the battery.

The traditional separator of the past, up to World War ll, was made from wood – not just any wood – one particular type of wood known as as Post Oxford Cedar was universally conceded to be the best. The wood was chemically treated to remove most of the resinous material, thus increasing the porosity, but it was then very weak and it could not be dried without shrinking, buckling and splitting. Consequently it had to remain wet thereafter, which meant that an assembled battery could be stored only for a limited period before it was filled with acid or otherwise undesirable changes would occur in the plates or the separators.

In service, although capable of a high level of performance, the wood separator had a limited life since it was gradually eaten away by oxidation, apart from being inherently mechanically weak and liable to split. As a result it was almost inevitably the first component of the battery to become unserviceable, breaking down, perforating, and allowing active-material to bridge across from positive to negative plates, to cause an electrical short which prevented the battery holding a charge.

The "Porvic" separator is made from unplasticised Polyvinyl Chloride, and it has a performance equal to the best wood separator whilst possessing superior mechanical properties and virtually unlimited life. It is "microporous," that is, it is not visibly porous, although in fact about 87% of its volume consists of minute cavities each communicating by ports with all the adjoioing cavities. The microporosity is given to the Polyvinyl Chloride (P.V.C. for short)

These deficiencies of the wood separator led many people to search for something better.

3. **Group:** The plates are welded to a lead antimony strap for forming the battery plate group. The strap is provided with a round post protruding through the cell cover hole. This forms the terminal . The fig.5 below shows the battery plate group.

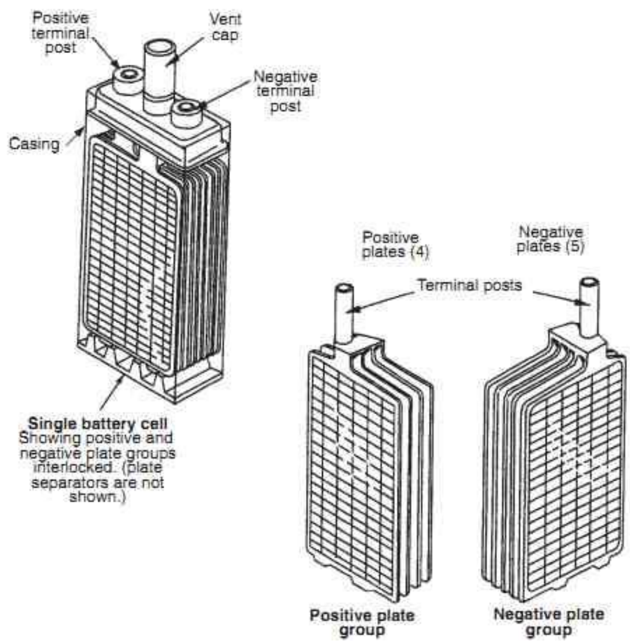


Fig.5 Battery plate group

4. **Element:** The battery element consists of two groups of plates - negative and positive which are assembled together. There is generally one negative plate more than the positive plate. For example a 19 plate cell will have 9 positive plates and 10 negative plates. This is done to make sure that there is a negative plate on each side of the positive plate. It is essential to have less positive plate area because there is more chemical activity at the positive plate. Each plate is separated by the separators from adjacent plate. Fig. 6 shows as assembled battery element which is then placed inside the container of the battery.

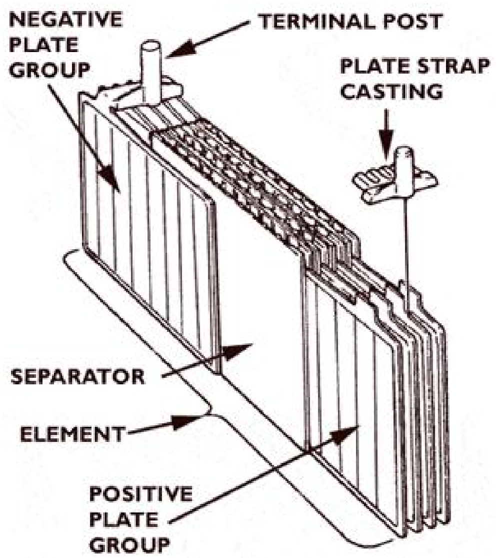


Fig. 6 Assembled battery element

5. **Container:** The assembled battery element is placed inside a hard rubber, acid-proof container with three or six compartments for 6 V and 12 V batteries respectively. There are ribs formed in the bottom of the container on which the plates rest. The space below and between the ribs is meant for storing the sediments resulting form the normal action of the battery during its service. Short circuiting of adjacent positive and negative plates is avoided by this arrangement. Fig. 7 shows a sectioned view of the container to show the ribs clearly at the bottom. The terminal posts and the plate tops are supported by cell covers of insulating and acid resisting material. Their shape is such that the joint between the container's compartment and the container cap can be sealed with the help of a battery compound.

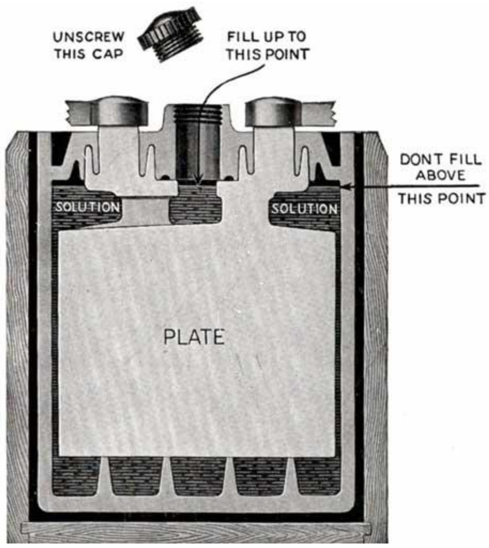


Fig.7 Cross section view of battery

6. **Electrolyte:** The electrolyte of automobile batteries is made by diluting sulphuric acid with water. It should be noted that acid should be poured into water and not vice-versa, as it will cause an explosion. A container made of rubber, china glass, lead or earth may be

used for preparing the electrolyte. No metallic container except that of lead should be used for this job. The electrolyte used in automobile batteries is of a higher density due to the following reasons.

i) The volume of the electrolyte is limited keeping in view the size and weight of the battery

ii) The automobile batteries are frequently required to give heavy discharge currents due to cranking motors.

Fig. 8 shows the curves of internal resistance and voltage of a battery.

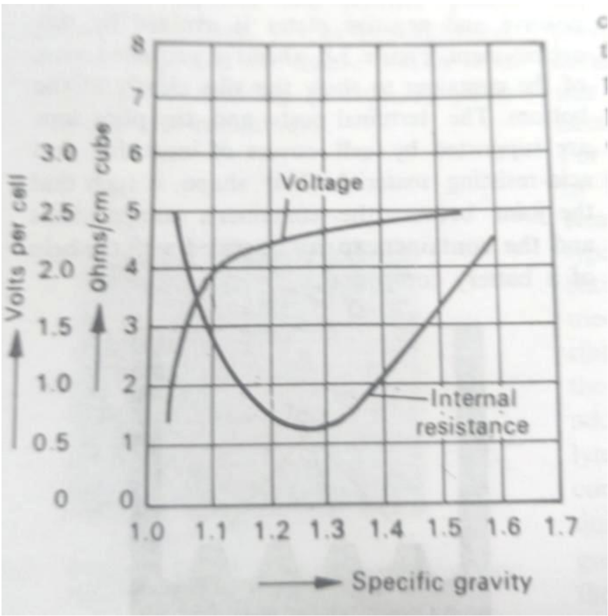
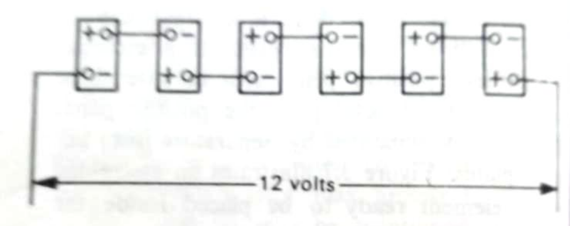
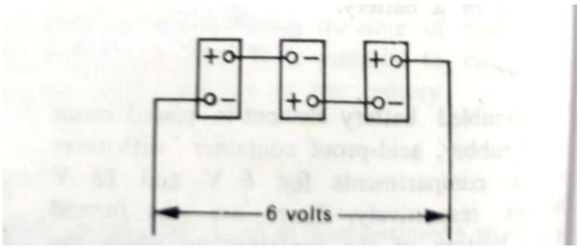


Fig. 8 internal resistance and voltage of a battery

The voltage of the battery is not much affected by the specific gravity of the electrolyte except for weak solution but there is a certain specific gravity as far as the resistance is concerned. The specific gravity range of 1.150-1.250 of the electrolyte produces the low internal resistance of the cell. The specific gravity of 1.220 gives the minimum internal resistance and it is the most suitable working specific gravity for batteries operating at normal rates.

7. **Cell Connectors:** The heavy lead bar cell connectors are attached to the cell terminals. The individual battery cells are connected in series, thus adding up their individual voltages. The fig. below shows the connections of six and three cells in series for 12 V and 6 V batteries respectively.





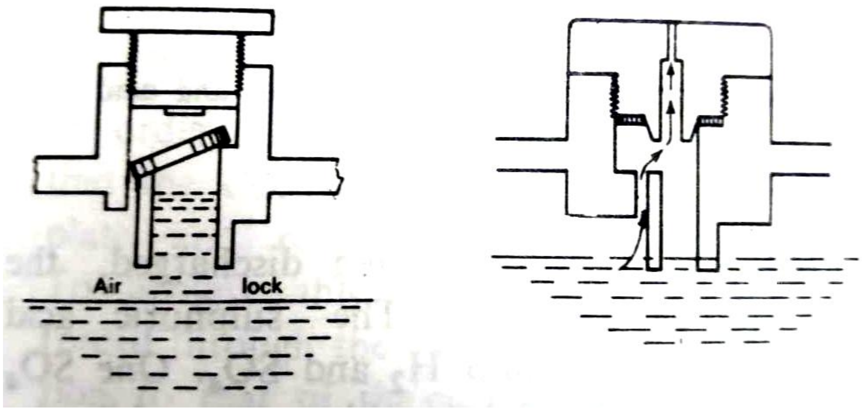
The cell connectors may be located above or in the cell covers in the automobile batteries. When the cell connectors are in the cell covers, a heavy coating of sealing compound is used to protect them. The leakage of current across the tops of cell covers is thus reduced by this type of construction. Due to the presence of moisture and dirt there is leakage of current through the electrical path formed across the terminals in case of exposed cell terminals.

There is another way of protecting the connectors and cell terminals of the battery by using a one-piece cover for covering all the cells. The connectors are used to connect cells that are made to pass through the partition between the cells.

8. **Vent Plug:** They are provided in the cell covers for the purpose of pouring the electrolyte and water when necessary. The vent plugs are screwed into the threaded holes provided in the covers. During battery action, water is lost, some by evaporation and some by conversion into hydrogen and oxygen. A hole is provided in the plug to permit escape of these gases. The vent plugs are provided with baffle plates. The gases emitted are likely to carry droplets of electrolyte along with them. These baffle plates trap these droplets of the electrolyte thus avoiding loss of the electrolyte.

There should be a proper level of the electrolyte in the cells of the battery. Addition of too much water in the cells will force the electrolyte out of the vent plugs when the battery is being charged. The electrolyte thus forced out of the battery will damage the engine and other body parts due to its corrosive action as well its loss reduces the operating capacity of the battery.

Electrolyte is prevented from overfilling the battery cells with the help of non-overfilling devices which are incorporated in the cell cover and the plug as shows in fig. below.



Here the air is trapped in the top of the cell when the plug is removed. This way only a proper amount of water can be added. On replacing the plug, the trapped air is released thereby providing space for expansion of the electrolyte due to gassing.