Current electricity

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Electric current

- Is a flow of electrons & produced when a difference of potential exists b/w the ends of conductor.
- The essentials for production of electric current
- A) a difference of potential(p.d)
- B) pathway along which current flows

Electromotive force

- A difference of potential give rise to a force known as electromotive force (EMF) which tends to produce electrons.
- If a pathway is provided the EMF produces a flow of electrons, but if there is no pathway so that no current can pass, the force still exists.
- Greater the p.d greater will be EMF.
- Both are measured in same unit , the Volt.
- A volt is that EMF which when applied to a conductor with a resistance of one Ohm produces a current of one ampere.

Resistance

- A pathway through which electrons can move is known as a circuit and conductor of which it is made offers some impedance to movement of electrons.
- The amount of resistance depends on
- 1) material of conductor
- 2) length of pathway
- 3) cross sectional area of conductor
- 4) temperature

Unit of resistance:

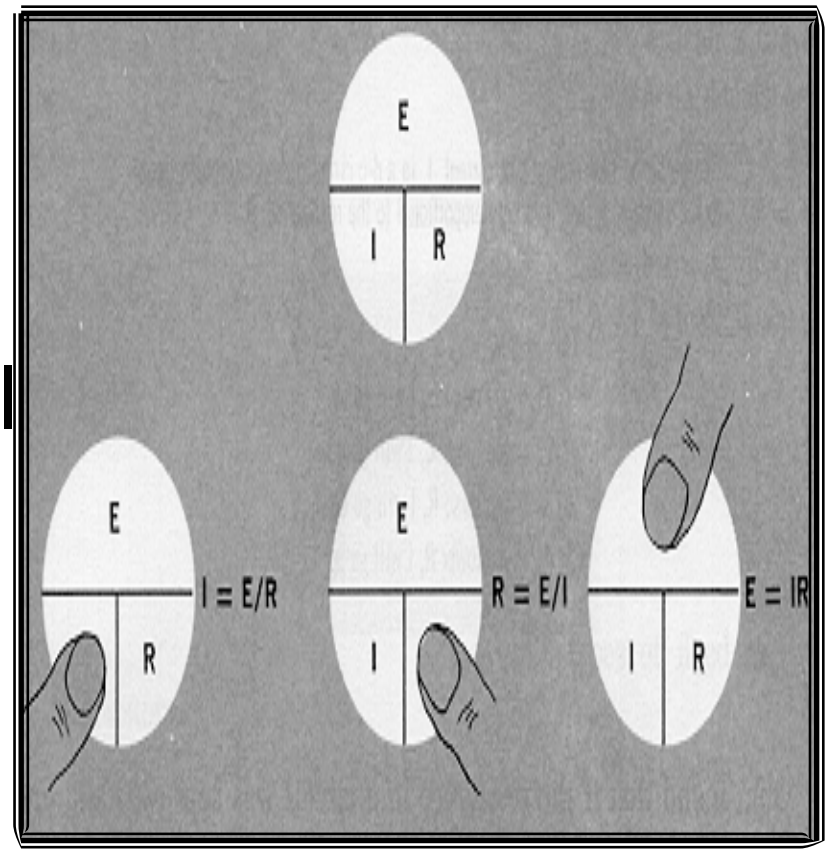
- **Ohm**
- Defined as the resistance offered by a column of mercury to 6.3 centimeters long and one square milimeter in cross sectional area at “0”centigrade

OR

- Resistance offered by 50 yards of copper wire one square milimeter in cross sectional area at STP.

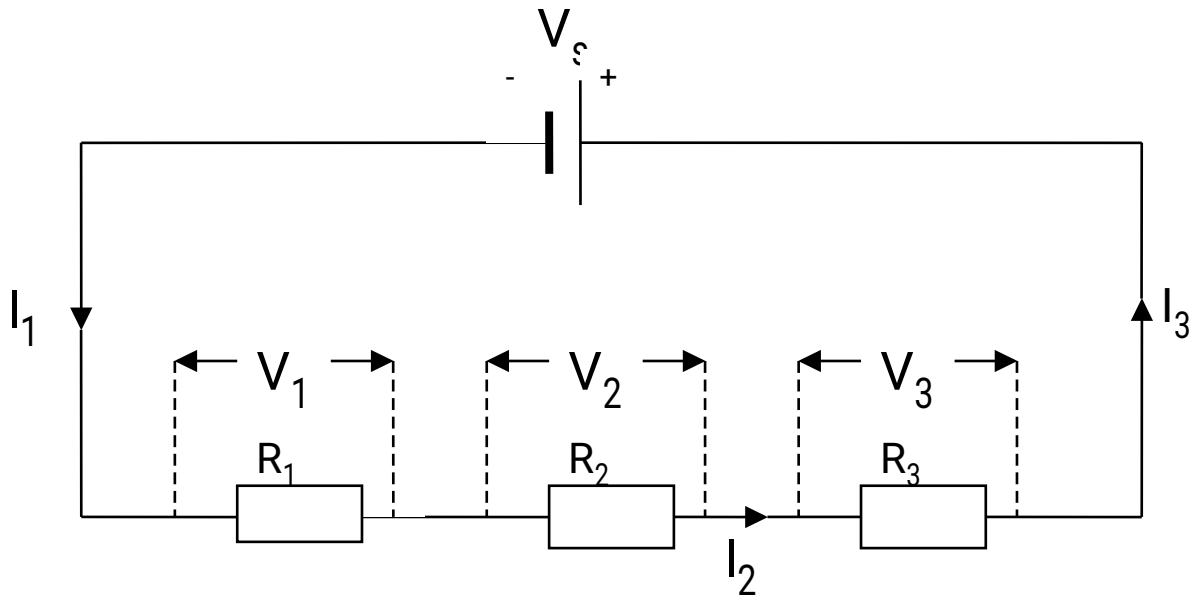
OHM'S LAW

- The relationship b/w EMF, resistance and intensity of current is stated in ohm'law as
- I=E/R or E=IR or R=E/I
- I= intensity of current
- E= EMF measured in vol
- R= resistance



Types of resistance

- Component part forming a circuit may be connected together in two different ways, in series and in parallel with each other.
- **Resistance in series:**
- The resistance are connected together end to end so that the current has only one pathway. Consequently current is compelled to pass through each of resistance in turn and total resistance is sum of individual resistance.
- Expressed by formula
- $R = r_1 + r_2 + r_3 \ldots\ldots\ldots\ldots r_n$
- where R is total resistance of r1, r2, r3 etc, individual resistance. All the current has to pass all resistance, the intensity of current is same throughout the circuit.
- A greater force is necessary to produce this current in parts of circuit with high resistance than those with low resistance.
- Consequently a force or potential drops by greater amount across high resistance than across low ones, so potential drops across each resistance is directly proportional to its resistance.
- The addition of more resistance in series increases the total resistance and reduces the intensity of current in all parts of circuit.



How do you find total resistance in series?

Add each resistance together.

$$R_{total} = R_1 + R_2 + R_3$$

Resistance in parallel

- Resistances are connected so that they tap the main circuit at two points, and thus provide alternative pathways for the current.
- As pathways are taken from the same points on the circuit, the potential drops across all of them is same. The intensity of current in each part varies directly with p.d and inversely with resistance of part of pathway.
- As the p.d across all is same the intensity of current in each parallel pathways is inversely proportional to resistance of pathway.
- Thus intensity of current is greater in low resistance pathways, least in those with high resistance.
- The intensity of current in each pathway is un-effected by that in the others and total intensity of current is sum of intensities in parallel pathways.

Continue.....

- The connection of resistance in parallel has the same effect an increasing the cross sectional area of conductor , this reduces the total resistance which is less than that of any individual resistance
- To calculate the total resistance following points are considerable.
- Total intensity of current is equal to sum of individual intensities in different parts.
- $I = i_1 + i_2 + i_3 \ldots\ldots\ldots i_n$
- Where I is total intensity and i_1, i_2, i_3 etc the intensities in different parts.

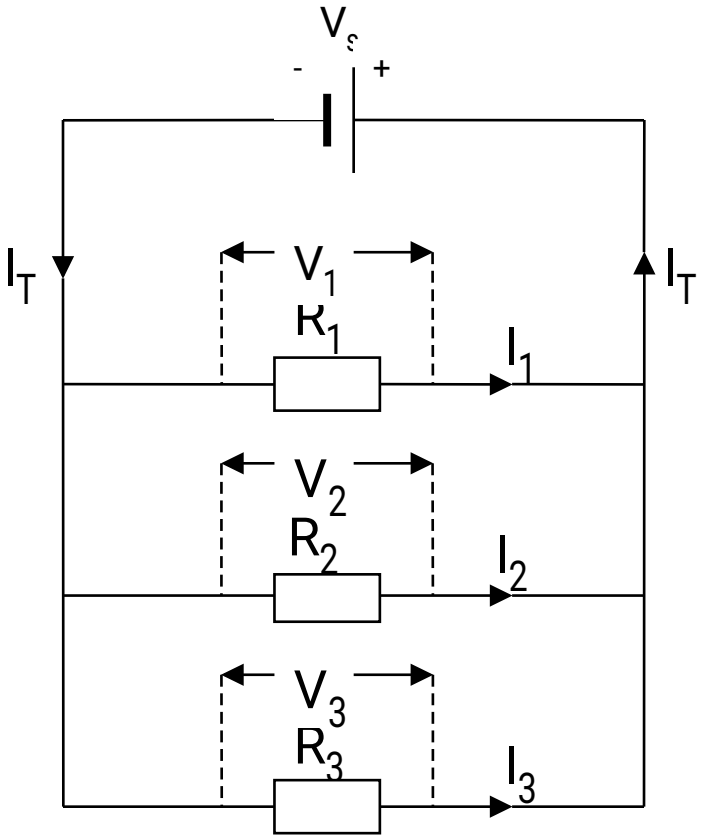
- By ohm's law I=E/R

E/R = E/r1 +E/r2 + E/r3……..E/rn

- Dividing trough by E,

1/R = 1/r1 + 1/r2 +1/r3……1/rn

- This formula can be used to measure total resistance in circuit and total resistance is less than any individual resistance in circuit.



The resistance in parallel?

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Battery

- Main type: storage battery
- Date: 1881
- a cell or connected group of cells that converts chemical energy into electrical energy by reversible chemical reactions and that may be recharged by passing a current through it in the direction opposite to that of its discharge -- called also storage cell.

Type of batteries

- The ***primary battery*** converts chemical energy to electrical energy ***directly,*** using the chemical materials within the cell to start the action.
- The ***secondary battery*** must first be ***charged*** with electrical energy before it can convert chemical energy to electrical energy.
- The ***secondary battery*** is frequently called a ***storage battery***, since it stores the energy that is supplied to it.

Lead acid battery

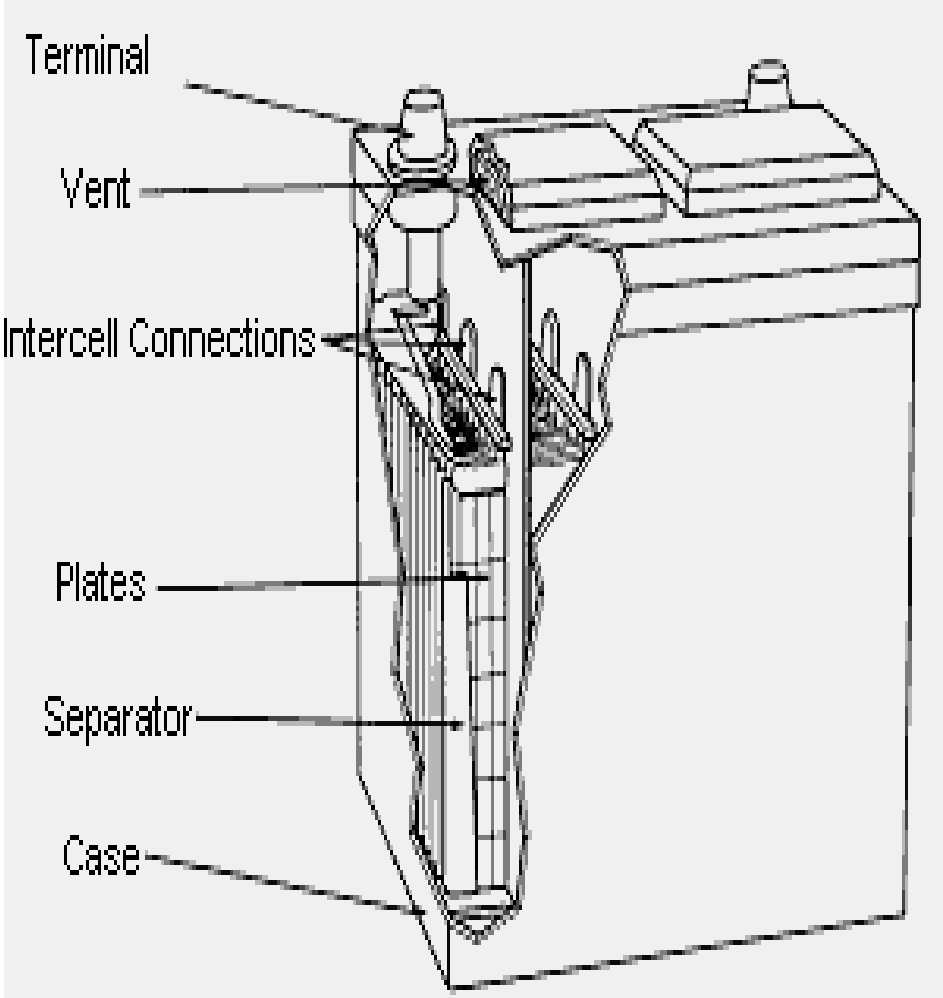


Figure 6 - Flodded Lead-Acid Battery

- Electrolyte for the most part distilled (pure) water, with some sulfuric acid mixed with the water.
- Electrodes must be of dissimilar metals.
- An active electrolyte.

Series Connected Batteries/cells

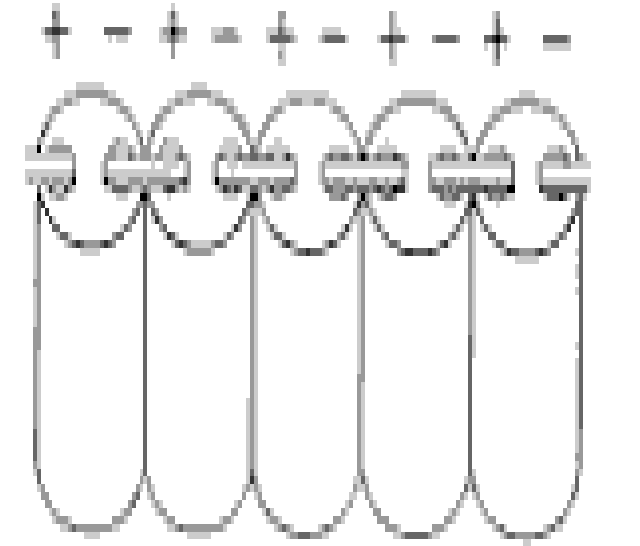


Figure 2 - Series-Connected Batteries

- Positive terminal of one cell is connected to the negative terminal of the next and so on…, is called a series connected battery.
- External circuit is taken from –ve terminal of 1st cell and +ve terminal of last cell.
- All current pass through each cell,
- The voltage/EMF of this type of battery is the sum of a individual cell voltages.
- V= v1+v2+v3…….vn
- internal resistance of battery is sum of internal resistance of individual cells.

Parallel Connected Batteries/cell

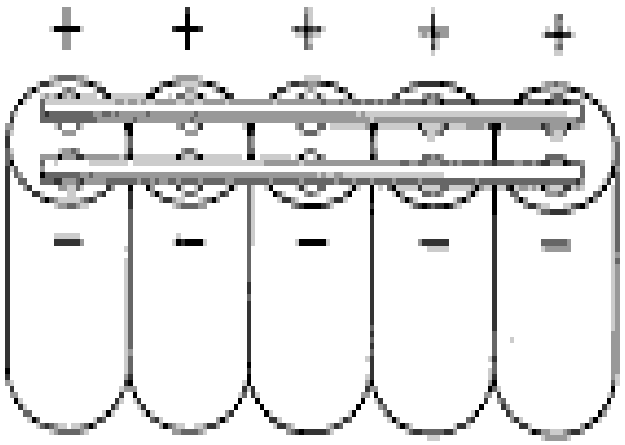
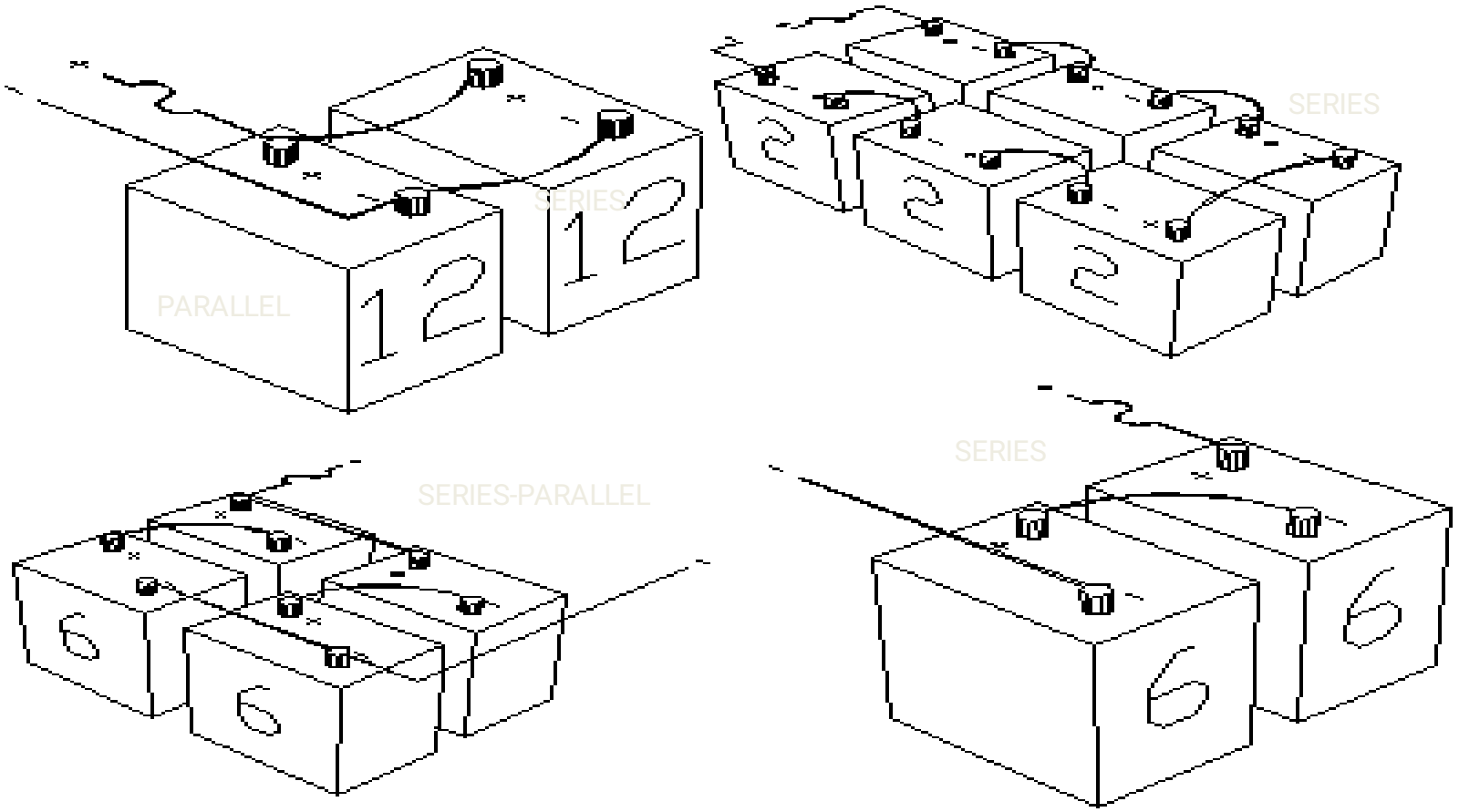


Figure 3 - Parallel-Connected Battery

- Connect the negative terminal from one cell to the negative of the next cell & so on.
- Connect the positive terminal to the positive terminal of next & so on, is parallel connected.
- The current pass through the external circuit from a common point where the negative terminal are connected together **to a** common point of junction of +ve terminals.
- Voltage/EMF remains constant as that of single cell and the current is cumulative.
- V= v1= v2= v3…… vn
- Internal resistance of battery reduced to less than that of one cell.

Series-Parallel Connections



Series and Parallel Batteries

- Parallel connection
  - increases the energy capacity of the battery set.
  - Cells must be matched for voltage
  - unmatched cells result in voltage with only internal resistance.
- Series-Parallel connections
  - combination of series and parallel calculations

Serial and Parallel batteries

- In series, the voltage is increased - the sum of the cells in series
  - Energy capacity is the same as that of a single cell (current = electrons/second
  - if unmatched cells are connected in series, the capacity will be that of the weakest cell.

Cells

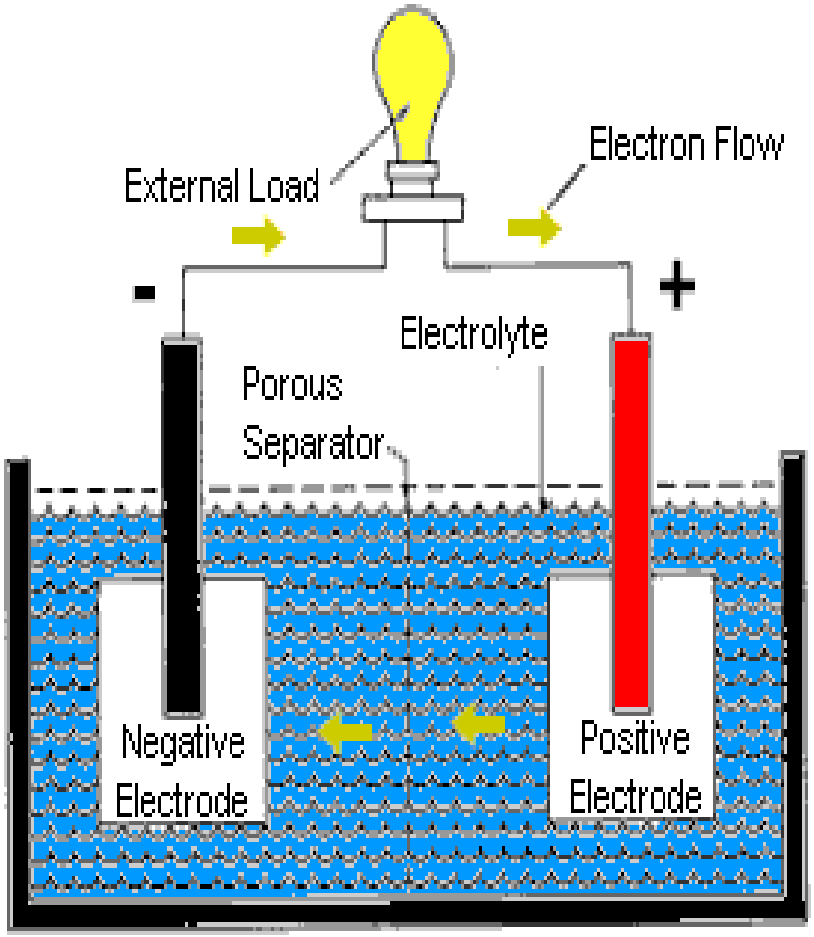
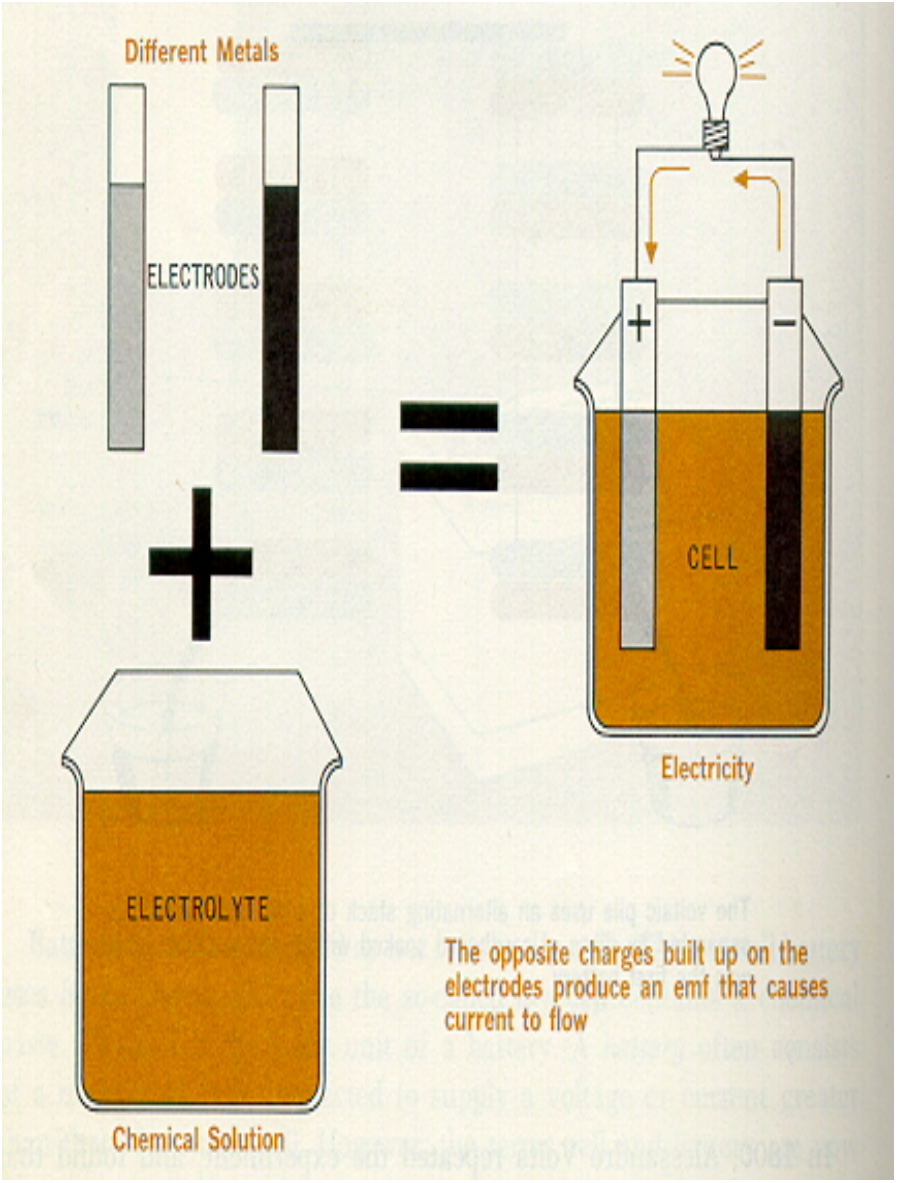


Figure 1 - Components of a Battery Cell (Discharge Circuit)

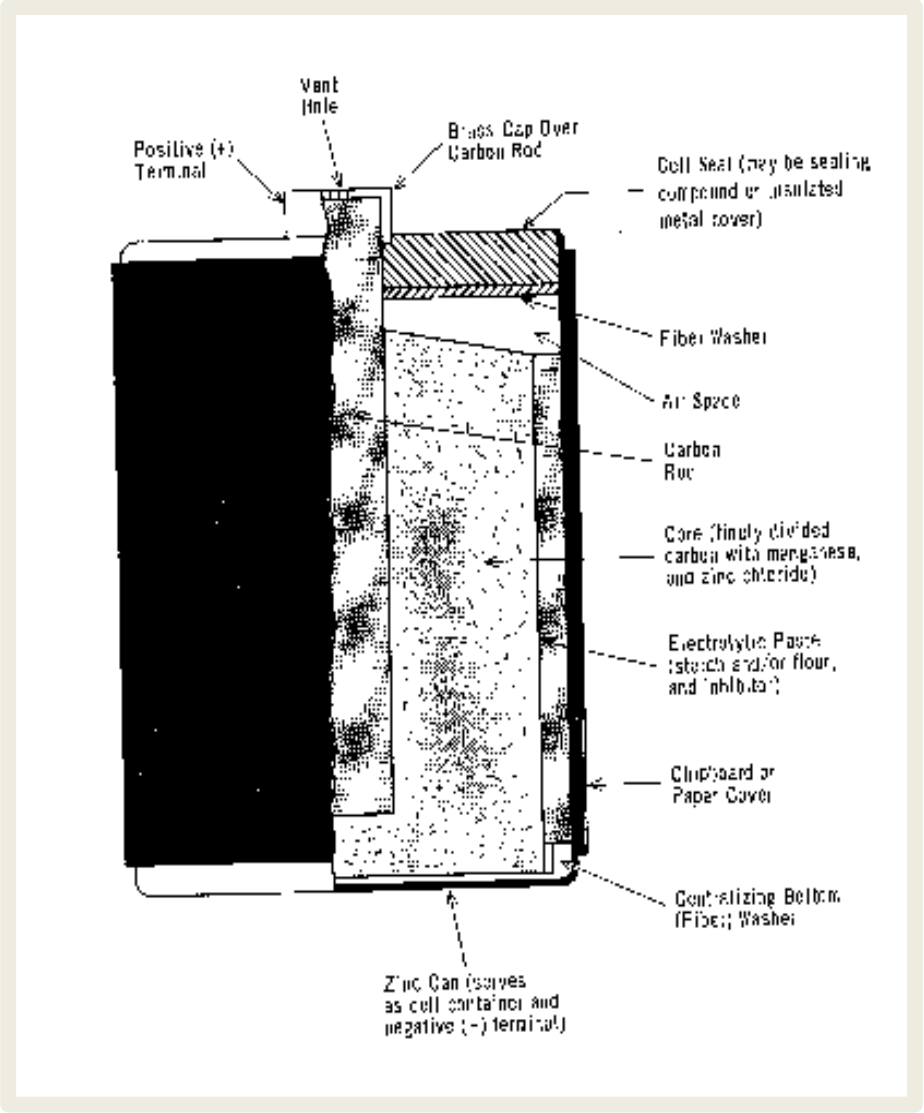
- Positive electrode
- Negative electrode
- Electrolyte
- Separator

Basic primary wet cell



- The metals in a cell are called the *electrodes*, and the chemical solution is called the *electrolyte*.
- The electrolyte reacts oppositely with the two different electrodes
- It causes one electrode to lose electrons and develop a *positive charge*; and it causes one other electrode to build a surplus of electrons and develop a *negative charge*.
- The difference in potential between the two electrode charges is the cell *voltage*.

Dry cell



- Uses An electrolytic paste.
- The electrolytic paste reacts with the electrodes to produce a negative charge on one electrode and a positive charge on the other.
- The difference of potential between the two electrodes is the output voltage.

DRY-CELLS

Not Rechargeable

As the reactants inside them become used up in chemical reactions, the output from these batteries gradually falls.

Once all the reactants have been used up, these batteries go “flat” and cannot supply electrical energy anymore.

RECHARGEABLE

Usually maintain a constant output until just before they go flat.

Once flat, it can be connected to a recharger. This uses electrical energy to reverse the chemical reactions that happened in the battery while it was in use.

E.g. Car batteries: they are constantly recharged while the car is moving, so the lights and horn will always work.

E.g. Mobile phones, MP3 players etc: must be recharged at regular intervals. It is usually recommended that such batteries should almost be flat before recharging. This allows the battery to be fully charged again.

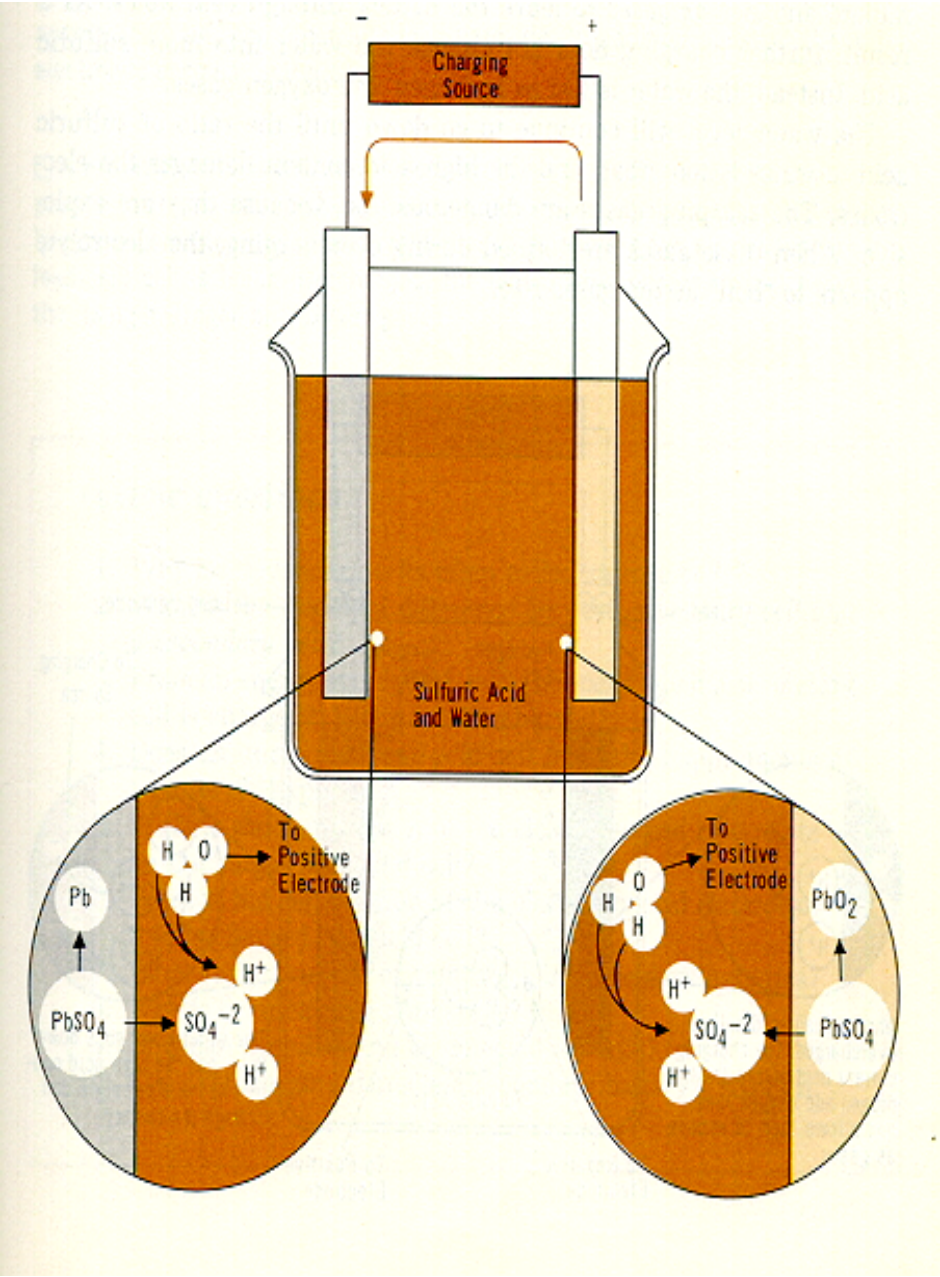
Which are best?

Non-rechargeable	Rechargeable
cheap to buy	often expensive to buy
can only be used once	can be used many times
expensive to use in the long run as more are needed (high cost / performance ratio)	cheap in the long run as they can be re-used (low cost / performance ratio)
output falls gradually with time	output stays constant until almost flat
disposal of many batteries creates a lot of chemical pollution	disposal of fewer batteries creates less chemical pollution

The Leclanche dry cell

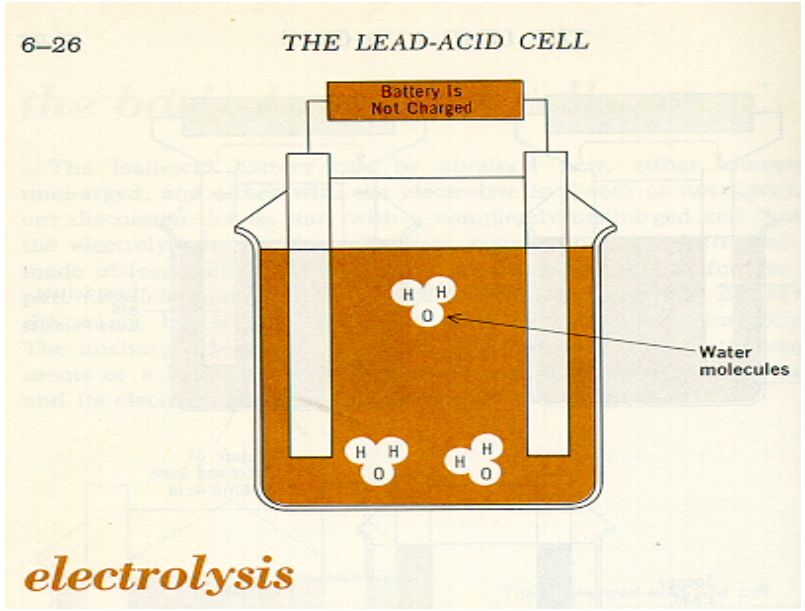
- There are various type of cell, different types made from different materials and giving different EMFs, but that in common use is the dry Leclanche cell.
- This consists of zinc and carbon electrodes in a solution of ammonium chloride. The carbon replaces the second metal and is surrounded by a mixture of powdered carbon and meganese dioxide.
- The ionic movement within cell results in zinc acquiring a negative and carbon a positive charge, the p.d between them being 1.5 volts.
- in dry Leclanche cell zinc forms the outer case of cell and wire coming it is negative terminal.
- The carbon electrode is a rod in the center of cell and its summit forms positive terminal.

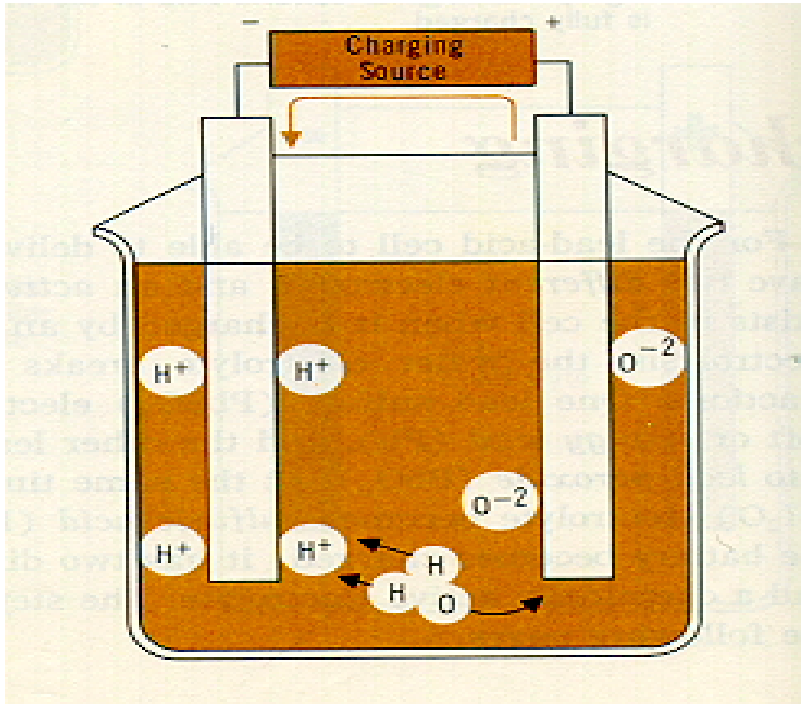
electrolytes



- When charging first started, electrolysis broke down each water molecule (H_2O) into two hydrogen ions (H^+) and one oxygen ion (O^{-2}).
- The positive hydrogen ions attracted negative sulfate ions (SO_4^{-2}) from each electrode.
- These combinations produce H_2SO_4, which is *sulfuric acid*.

Electrolysis





- The producing of chemical changes by passage of an electric current through an electrolyte. **Electrolysis**

- When charging fist starts, the current flowing through the battery causes *electrolysis* of the water.
- The water molecules (H_2O) begin to break down into their constituent ions.
- For each *negative* oxygen ion (O^{-2}) that is produced, there are two *positive* hydrogen *ions* (H^+), so that the electrolyte is neutral.