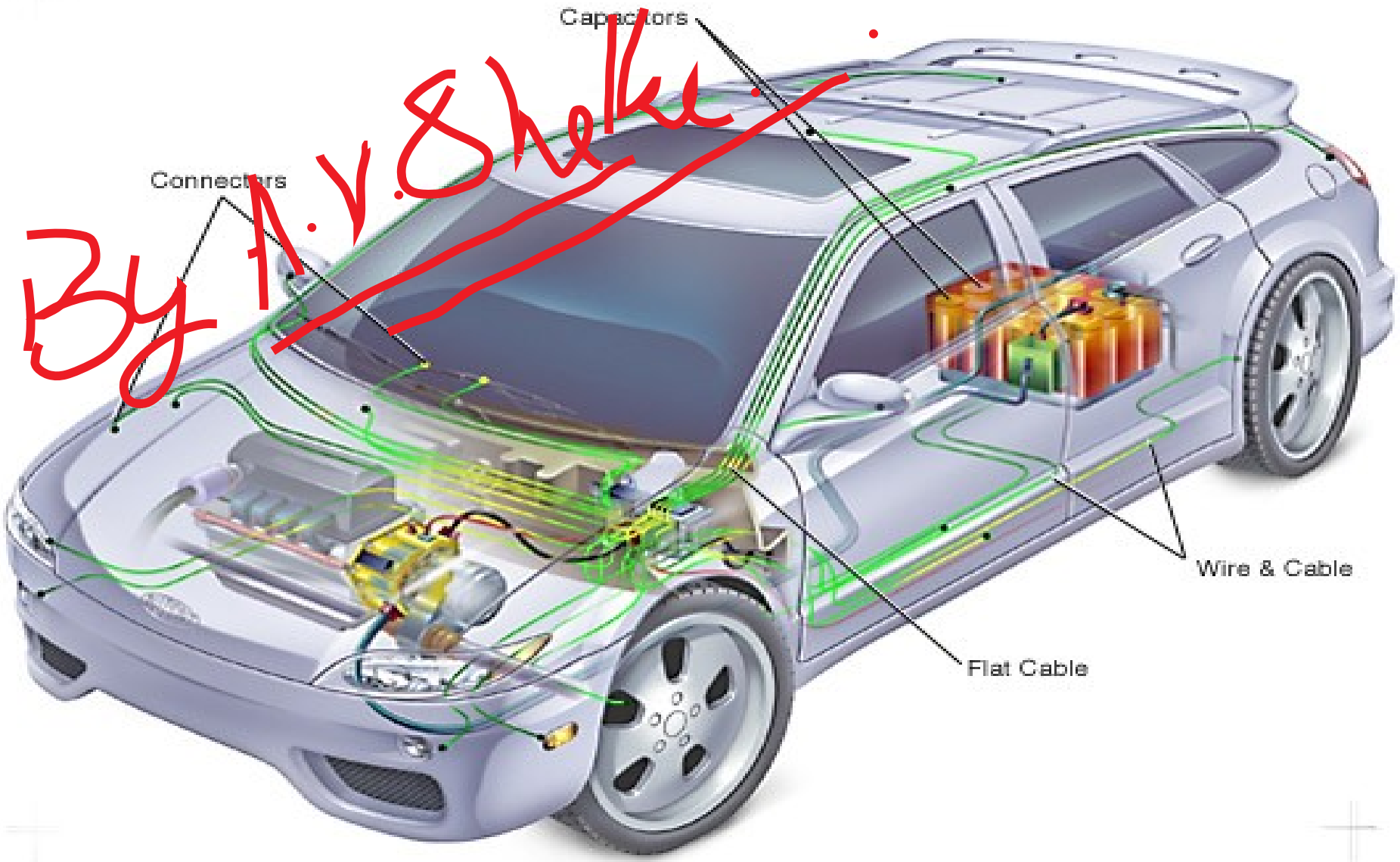
Automotive Starting and Charging System



By A.V.Shete

Automotive Battery

- An important component in the auto electrical system
- All batteries used in modern automotive applications are of the lead-acid storage type
- Essentially, a lead-acid storage battery is an electro-chemical device for storing energy in chemical form
- This energy can be released as electricity when connected to an outside circuit. A battery can perform this operation repeatedly

Battery-Functions

- To provide current for the starter and ignition system when cranking
- To provide the extra power necessary when the vehicle's electrical load (radio, lights, etc) exceeds the supply from the charging system current
- To act as a voltage stabilizer or reservoir in the electrical system, so that evens out voltage spikes and prevents them from damaging other components in the electrical system

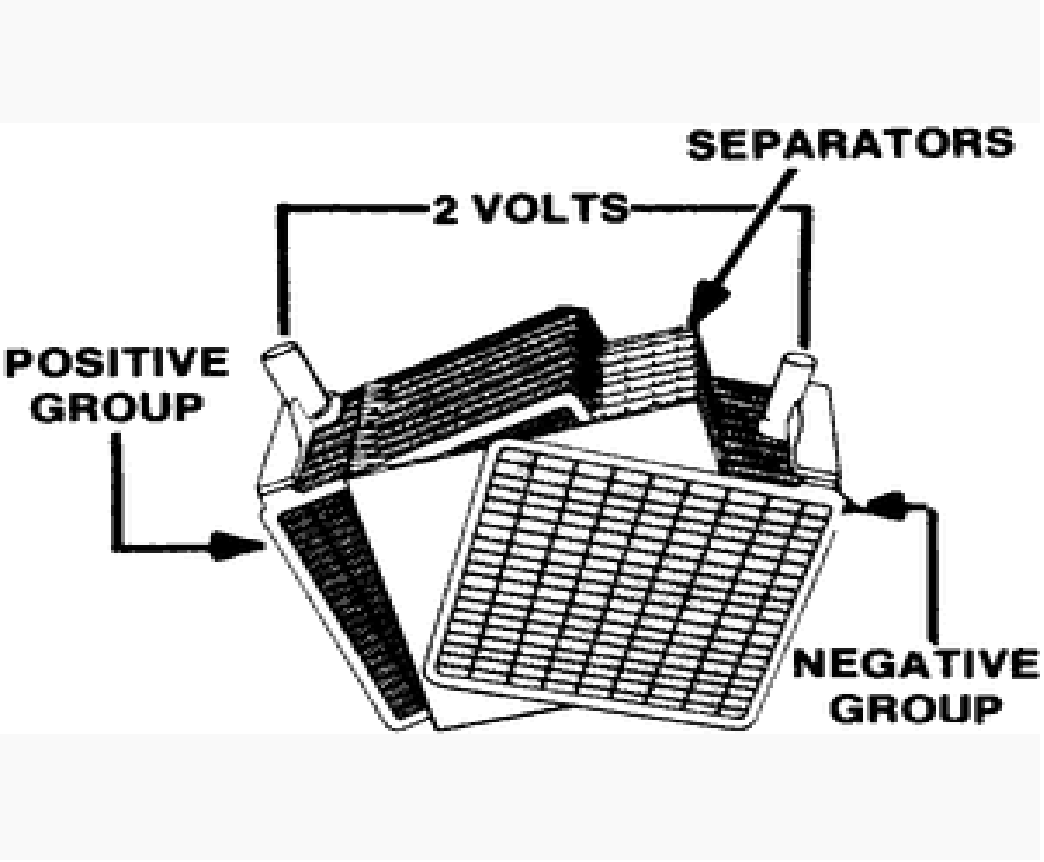
Battery components

- Plate grids
- Separators
- Electrolyte
- Containers , Terminals & Vent caps

Plate grids & Separators

- not an active part in the production of electricity, a good conductor to support the flow of electricity
- two types of plates -- positive negative plates. The positive plates are grids (lead-antimony alloy) pasted with active lead peroxide. This dark brown crystalline material has a high degree of porosity in order to allow the electrolyte to penetrate the plate freely
- negative plates are grids pasted with a type of lead (sponge lead) which is simply finely ground lead. Grinding the lead allows the electrolyte to penetrate the grid
- the more plates (or the larger the plates), the more energy the battery can store and release. The negative plates will always outnumber the positive plates by one for reasons of improved performance
- to prevent the plates from touching (short circuit), thin sheets of non-conductive porous material called separators are used. These are placed between every positive and negative plate

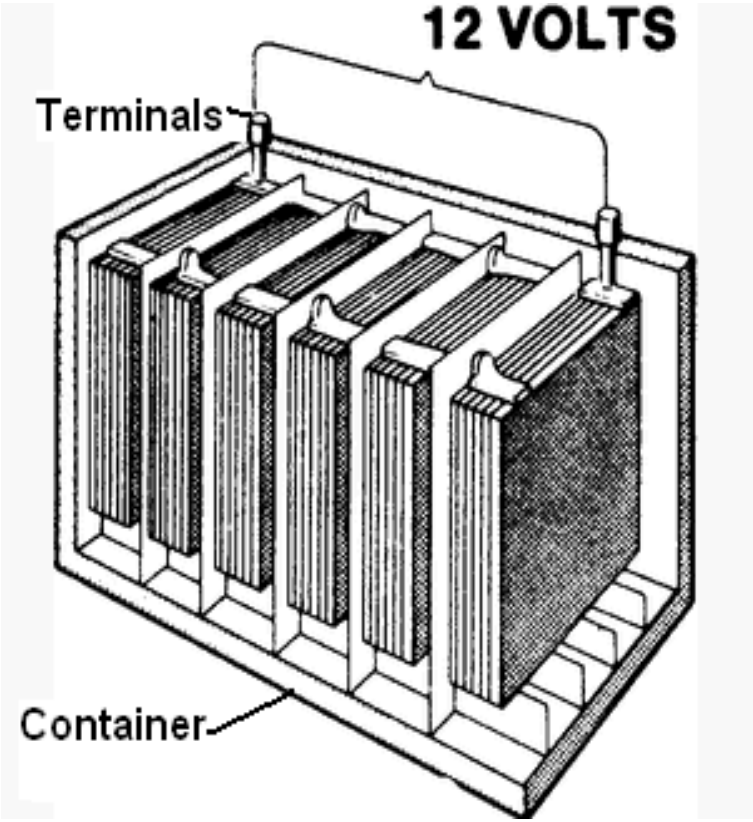
Plate grids & Separators



Electrolyte

- mixture of sulfuric acid and water
- ordinarily, the electrolyte used in a fully charged battery contains about 25% sulfuric acid and 75% water
- the strength or percentage of the sulfuric acid in the solution is measured by its specific gravity, that is, the density of the electrolyte versus the density of pure water
- the specific gravity or electrolyte strength of a fully charged battery is in the range of 1.260-1.275. This means that its electrolyte is at least 1.260 times heavier than pure water

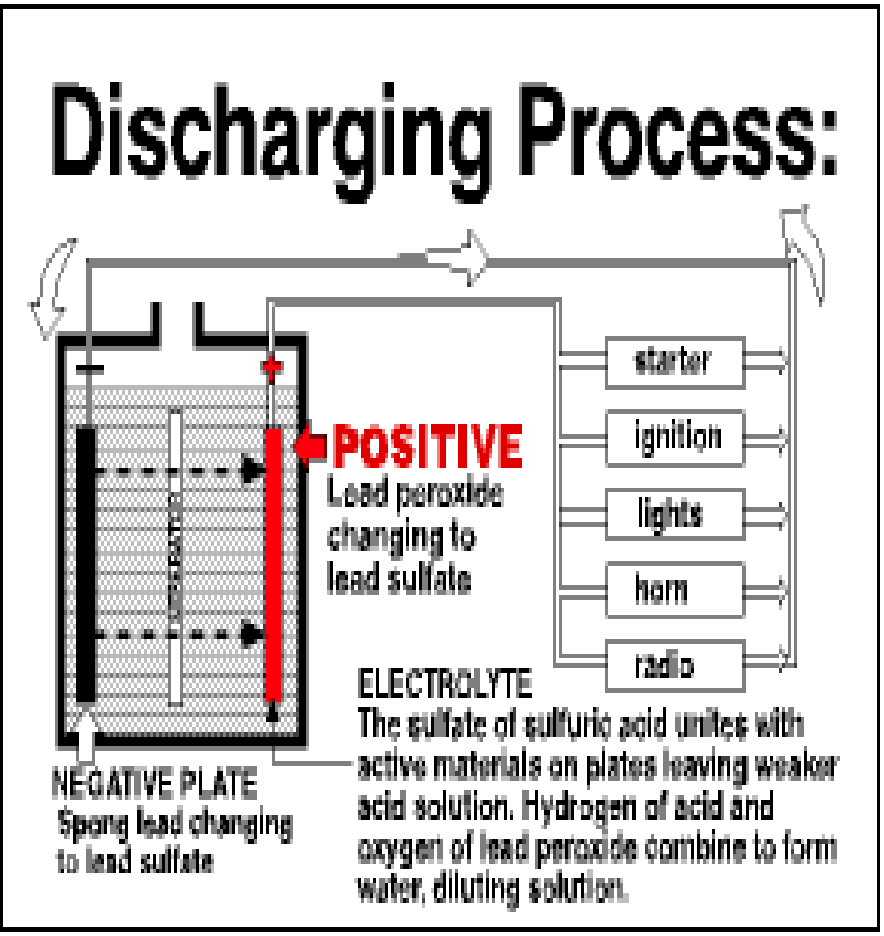
Containers , Terminals & Vent caps



How battery works

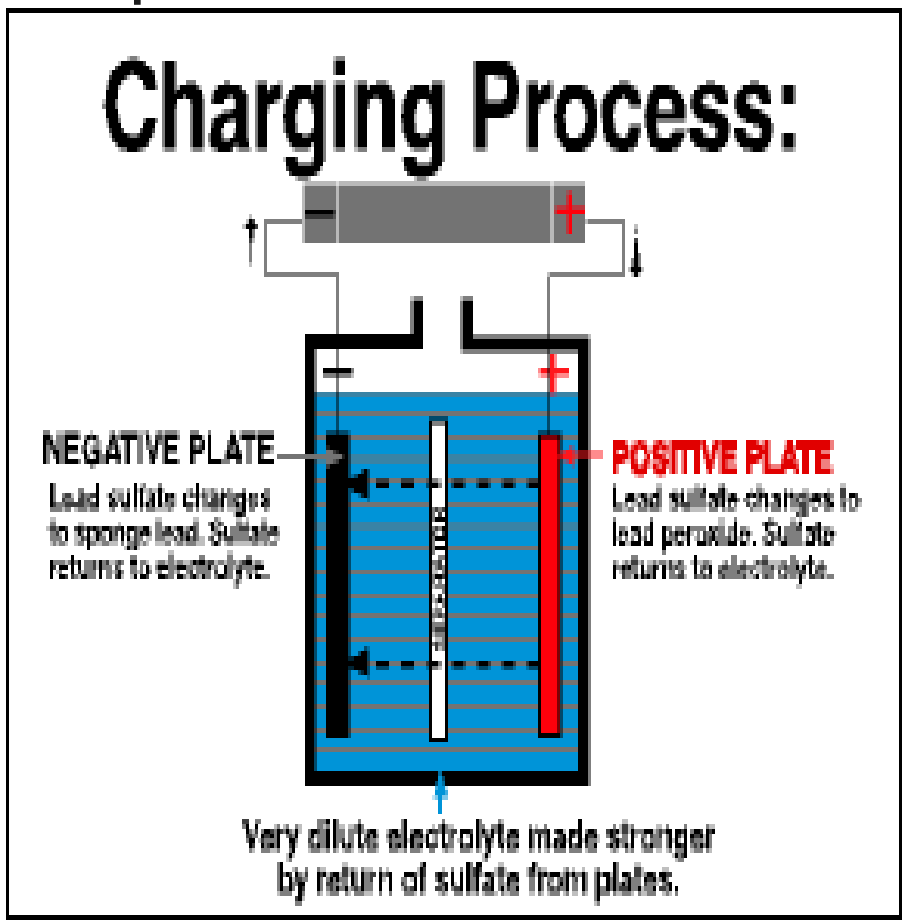
- The most important attribute of a lead - acid storage battery is its chemical reversibility, i.e operates in a constant process of charge and discharge.
- When a battery is connected to a load that needs electricity, such as the starter in your car, current flows from the battery. The battery begins to be discharged.
- In the reverse process, it becomes charged when current flows back into it
- Through a chemical reaction, the battery's active chemicals will be restored to a state of charge

Battery discharging



- The discharge process in a battery is begun as soon as an electrical circuit is completed, such as turning on the vehicle lights
- Current flows from the battery through the positive terminal
- During the time sulfuric acid works on both the plates' active material
- The chemical reactions form lead sulphate on plates so, liberating water, which reduces the concentration of acid in the electrolyte
- The amount of acid consumed by the plates is in direct proportion to the amount of energy removed from the cell

Battery charging



- To recharge the battery, it is only necessary to reverse the flow of current provided by the alternator through the positive terminal and out the negative battery terminal
- The sulphate that formed on the plates during discharge is changed back to sponge lead, and the sulfur returns to the electrolyte, forming sulfuric acid again
- At the positive plate, the lead sulfate changes to lead peroxide and returns even more sulfuric acid to the electrolyte

Battery testing

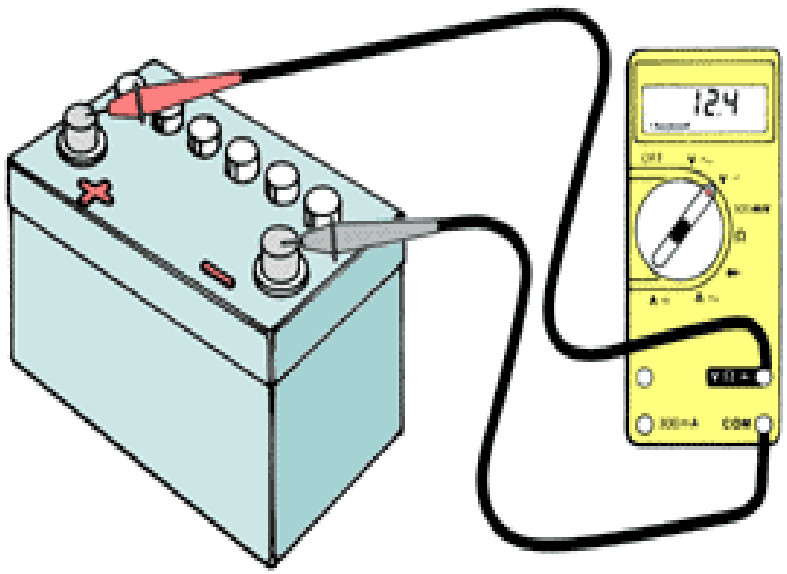
To determine if the battery

- is in good condition
- is charged
- is defective and should be discarded

Tests available

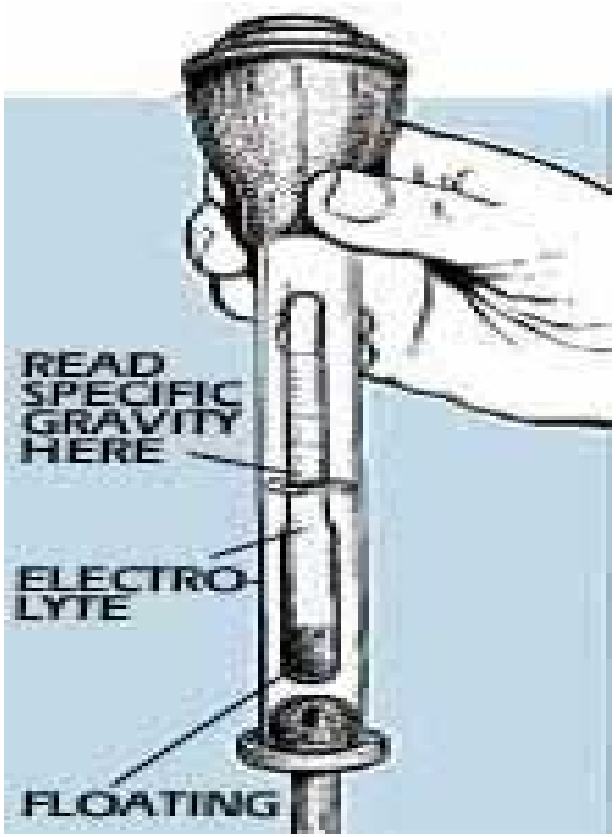
- Open Circuit Voltage (OCV) Test
- Specific Gravity Test
- Load Test

Open Circuit Voltage test



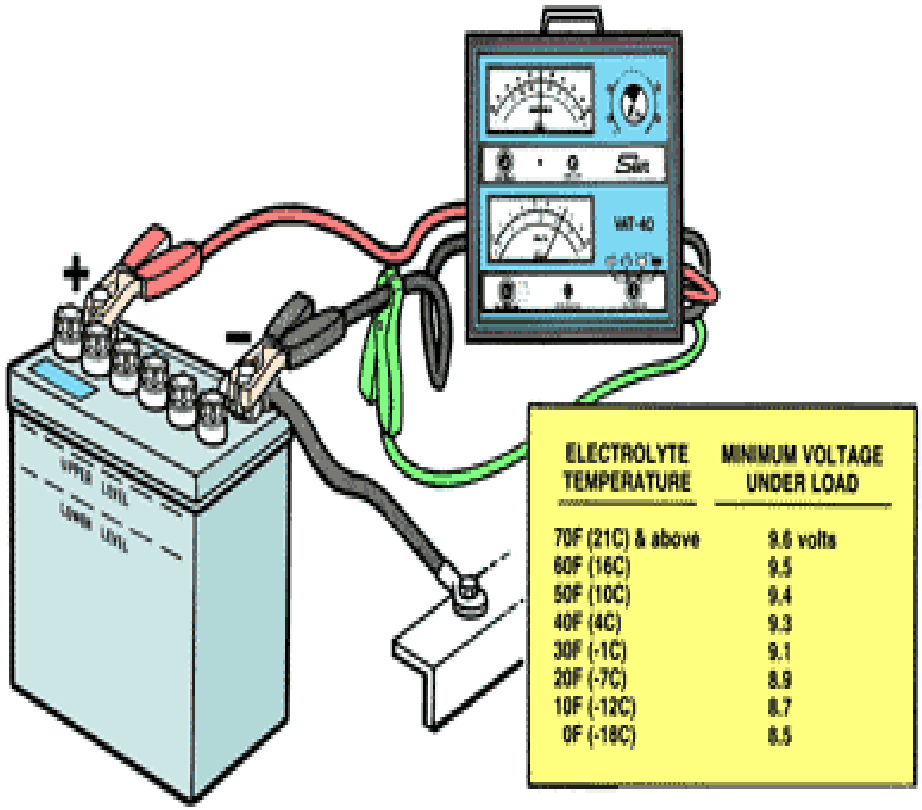
- An OCV test is performed with a voltmeter.
- Turn off all electrical loads and the charging source
- For an accurate reading, allow the battery to sit with no electrical loads applied for at least one hour
- Connect a voltmeter to the positive and negative terminals and measure the terminal post voltage with no loads or chargers connected to the battery
- Voltage less than 12.4 V needs charging

Specific Gravity Test



- This test is performed with a hydrometer
- Draw electrolyte into the hydrometer a few times so that the float reaches the same temperature as the electrolyte
- When you draw the electrolyte, make sure that the hydrometer is full
- Check each individual battery cell
- A reading of 1.265 or greater at 80^{0}F indicates a full charge
- 1.11-1.14 completely discharged

Load test

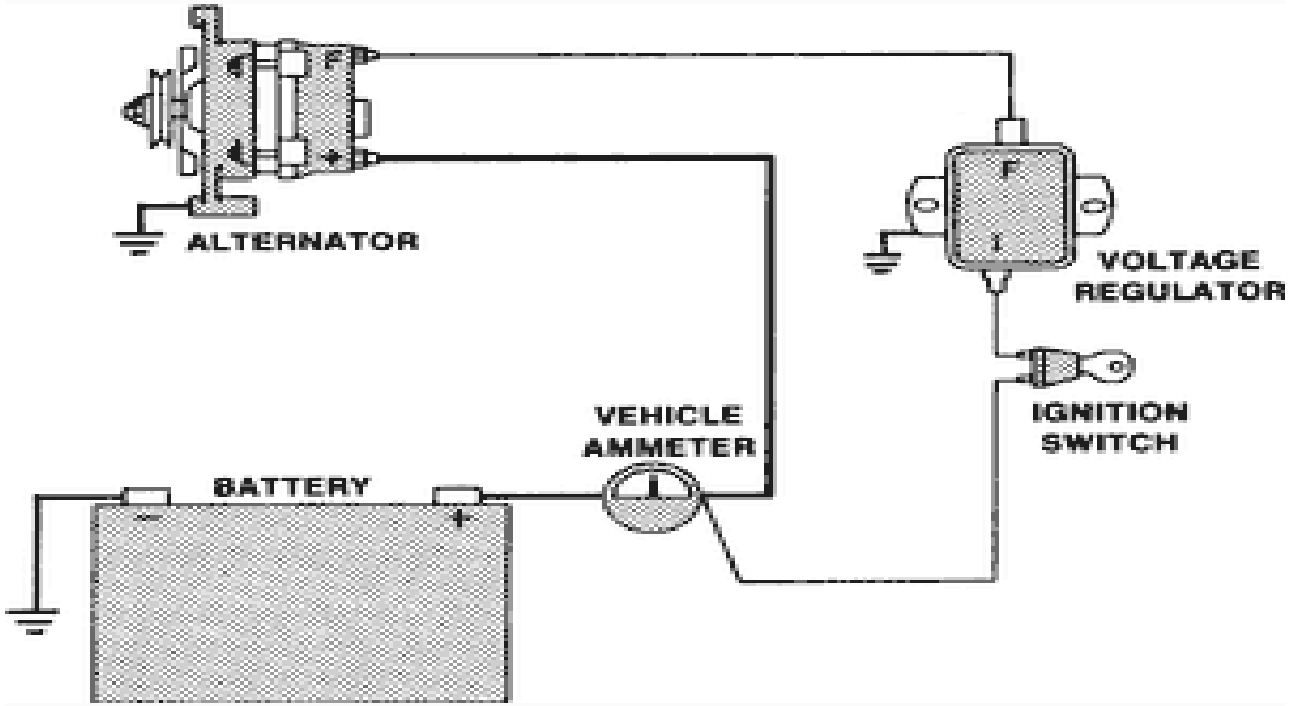


- Measures terminal voltage while discharging at a high rate
- Load is applied using a tester includes ammeter, voltmeter and a resistor
- This test is a 15-second discharge of the battery at a 1/2 cold cranking amp level
- Depending on temperature it should read the minimum voltage (ex. 9.6V at 21°C)

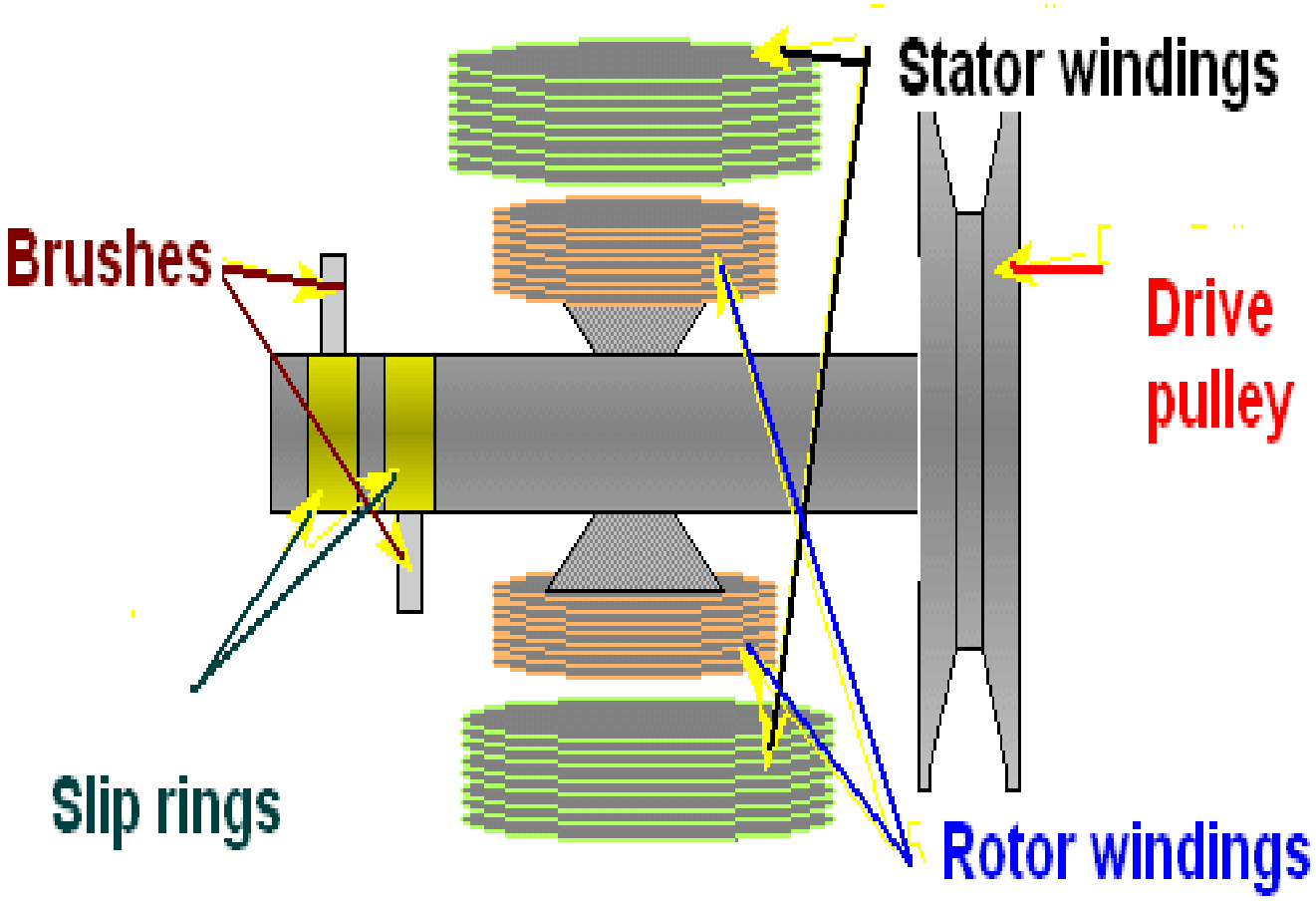
Charging system

- It includes the alternator, voltage regulator (which is often a part of the alternator itself), the battery, and the indicator gauge or warning light on the dash
- The charging system's job is to generate enough current to keep the battery fully charged, and to satisfy the demands of the ignition and electrical systems
- The voltage regulator senses the demands on the electrical system, and controls alternator output so sufficient current is produced. A loose V-belt, or a defective alternator or voltage regulator can cause the dash warning light to glow red (or the amp gauge to show and steady discharge)
- As long as the engine is running, all of the power for the accessories is delivered by the alternator. The battery is actually a load on the charging system. The only time that the battery would supply power with the engine running is when the current capacity of the alternator is exceeded or when engine is at a very low idle

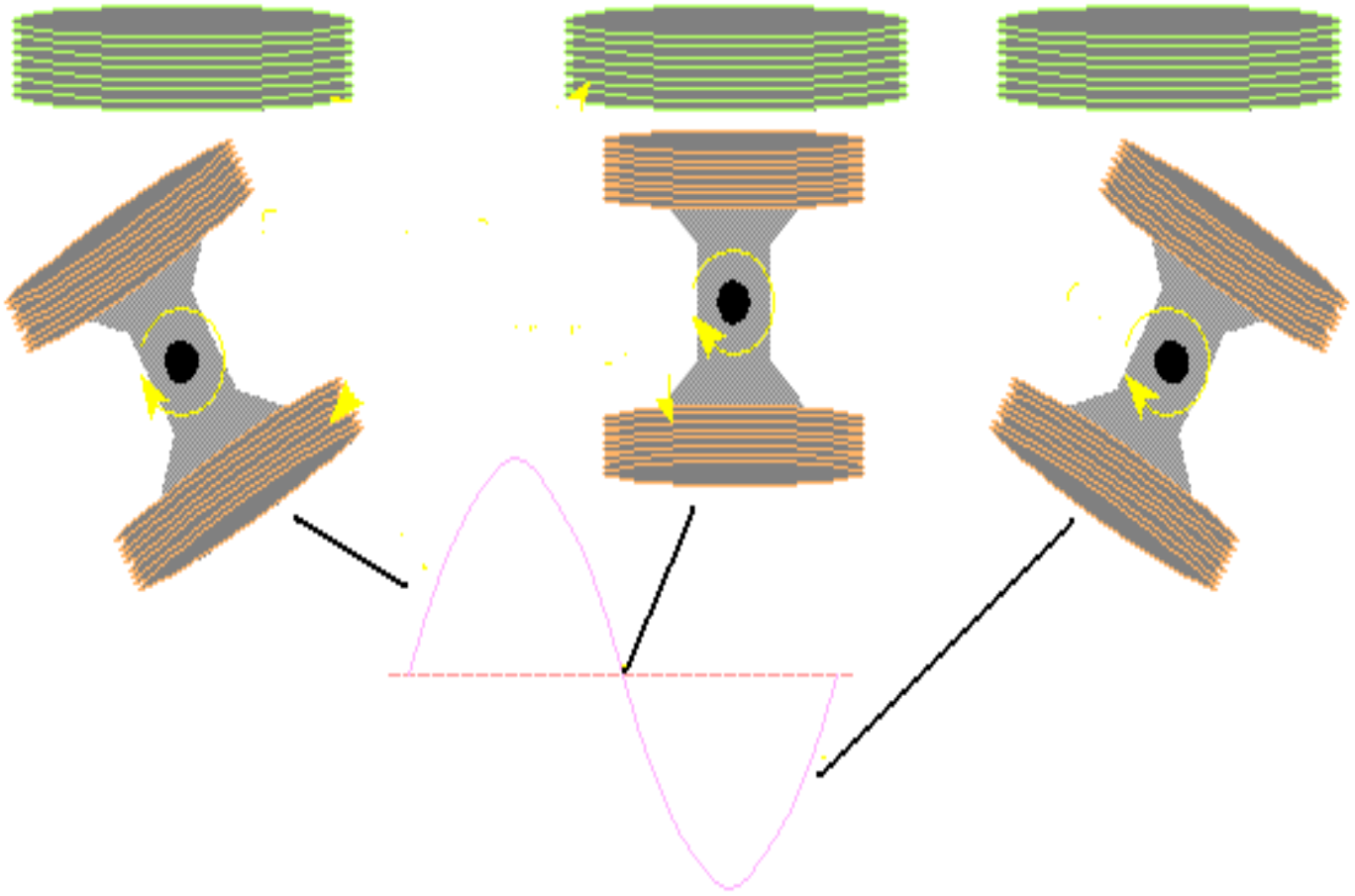
Charging system-Schematic



Alternator

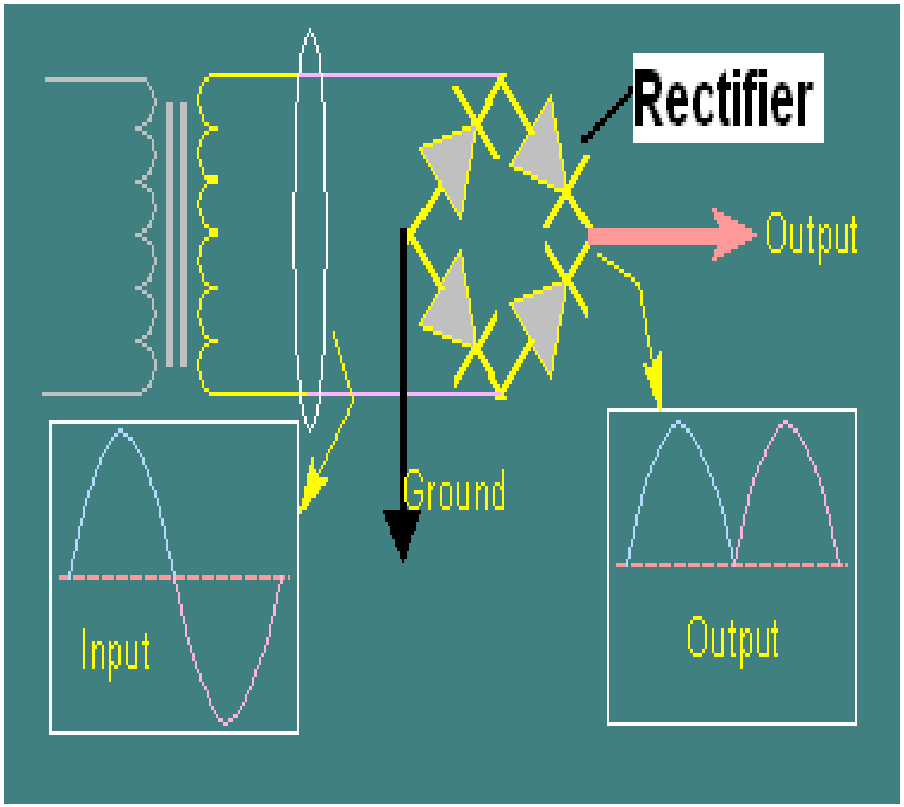

Stator windings
Brushes
Drive pulley
Slip rings
Rotor windings

Alternator in action

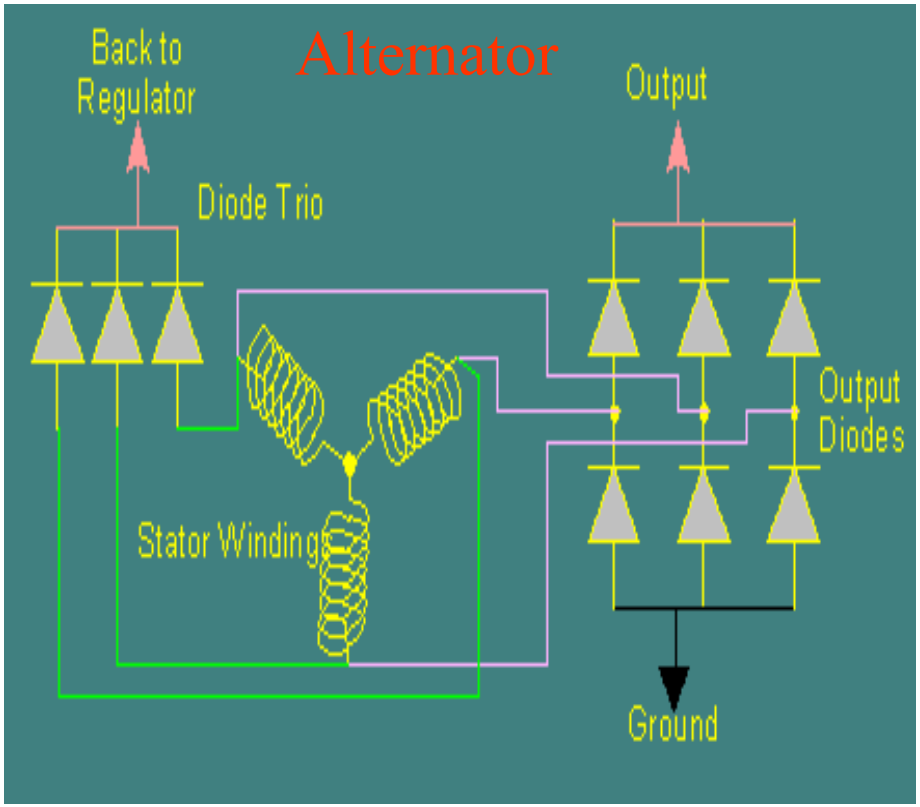


Rectification

For Transformer



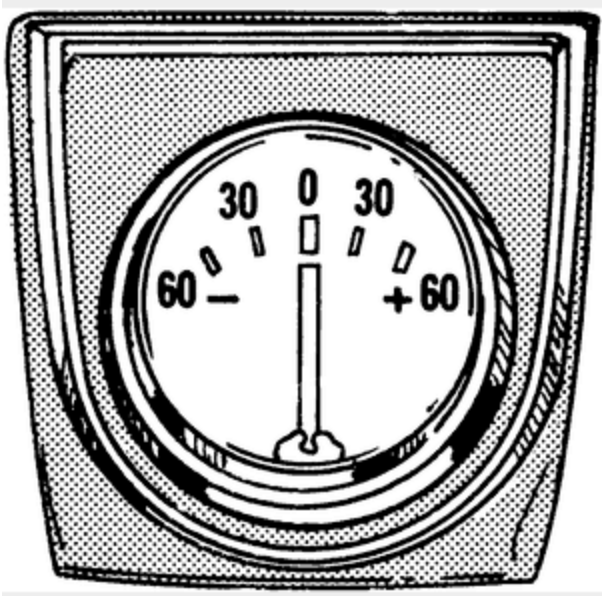
For Alternator



Voltage regulator

- The voltage regulator controls the field current applied to the alternator
- When there is no current applied to the field, there is no voltage produced from the alternator. When voltage drops below 13.5 the regulator will apply current to the field and the alternator will start charging
- When the voltage exceeds 14.5 the regulator will stop supplying voltage and the alternator will stop charging
- Current is regulated by the state of charge of the battery and demand
- During high engine speeds and low current demands, the regulator will adjust the field current to lower the alternator output voltage. Conversely, when the vehicle is idling and the current demands may be high, the regulator will increase the field current, increasing the output of the alternator

The warning indicator light or ammeter

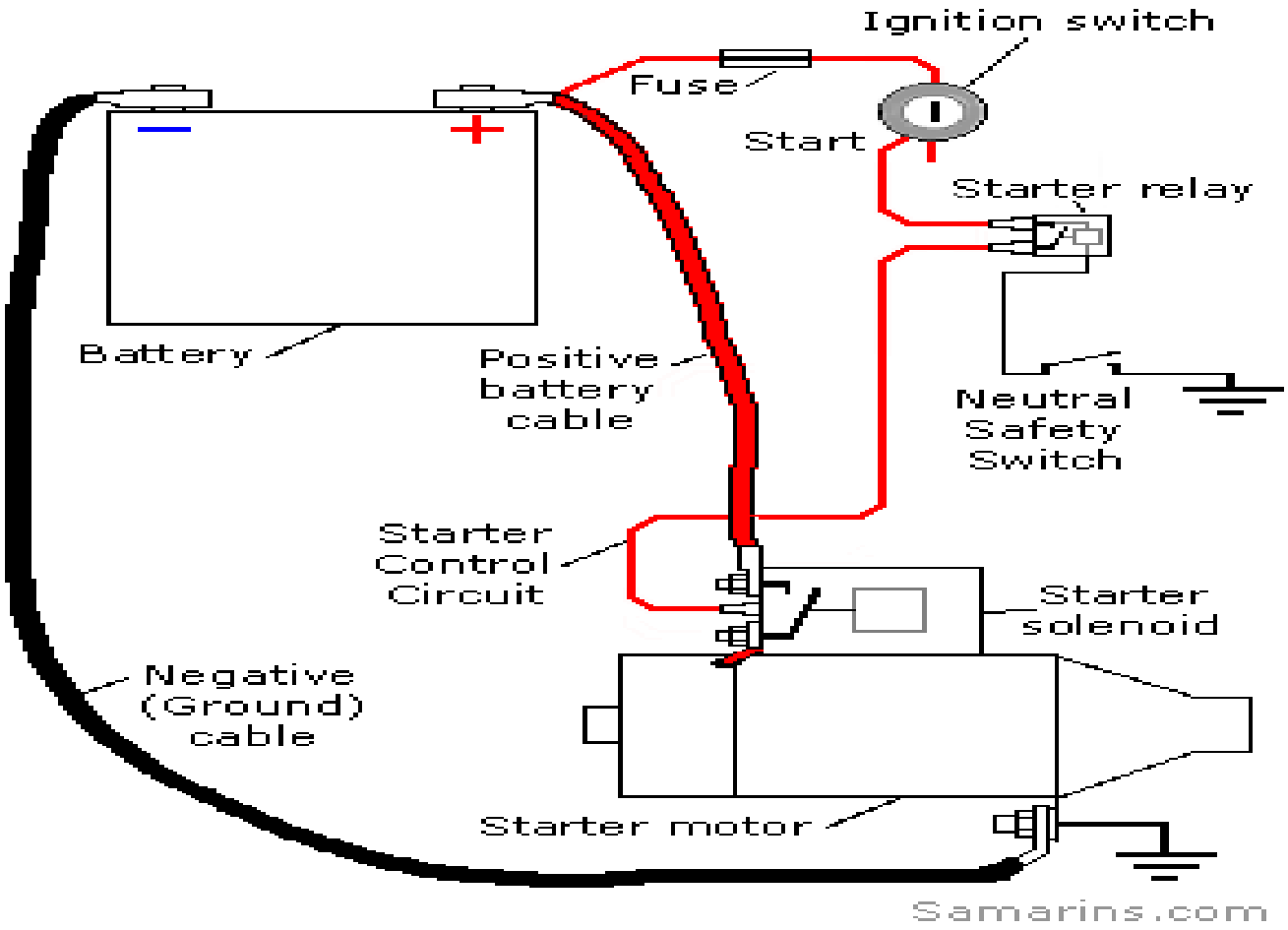


- To alert the driver of a malfunction in the charging system
- The bulb circuit is connected to the battery and alternator sides, any movement of current between the two units will cause the bulb to light
- If either the battery or the alternator should fail as the vehicle is being driven, the difference of voltage between the two units will allow current to flow and the bulb to light, warning the driver of a malfunction.
- An ammeter also indicates the condition of the charging system. A low battery will be indicated by a high charging current (+). A wiring short or faulty accessory will show as a high rate of discharge (-)

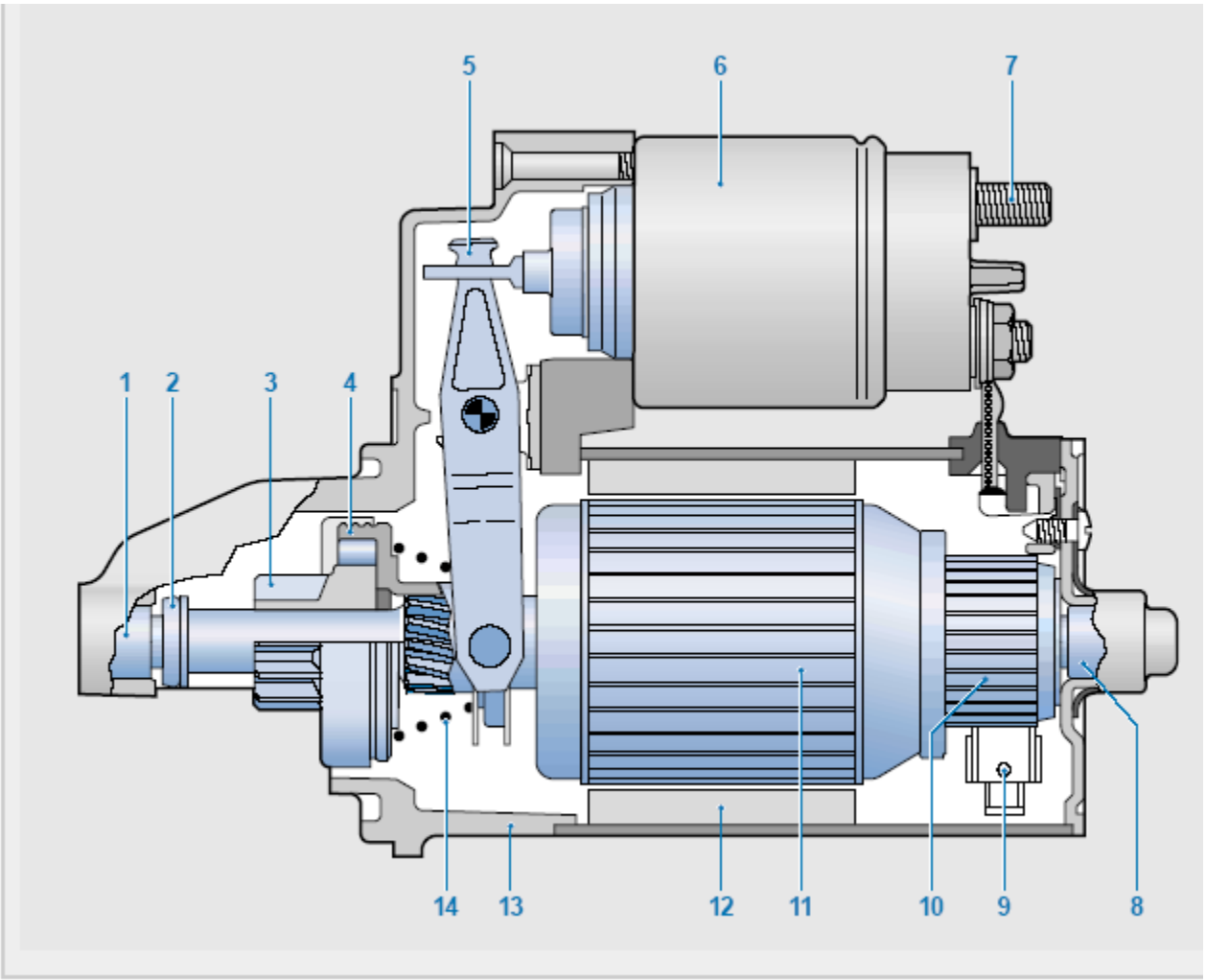
Starting System

- The purpose of the starting system is to convert chemical energy stored in the battery into electrical energy, then into mechanical energy in the starter motor
- This mechanical energy is then transferred through gears and drives from the starter motor to the engine flywheel
- The rotation must be of sufficient speed to allow the engine to form the combustible air-fuel mixture required for starting
- It must be maintained during initial combustion long enough until the engine can sustain operation

Starting System-Schematic

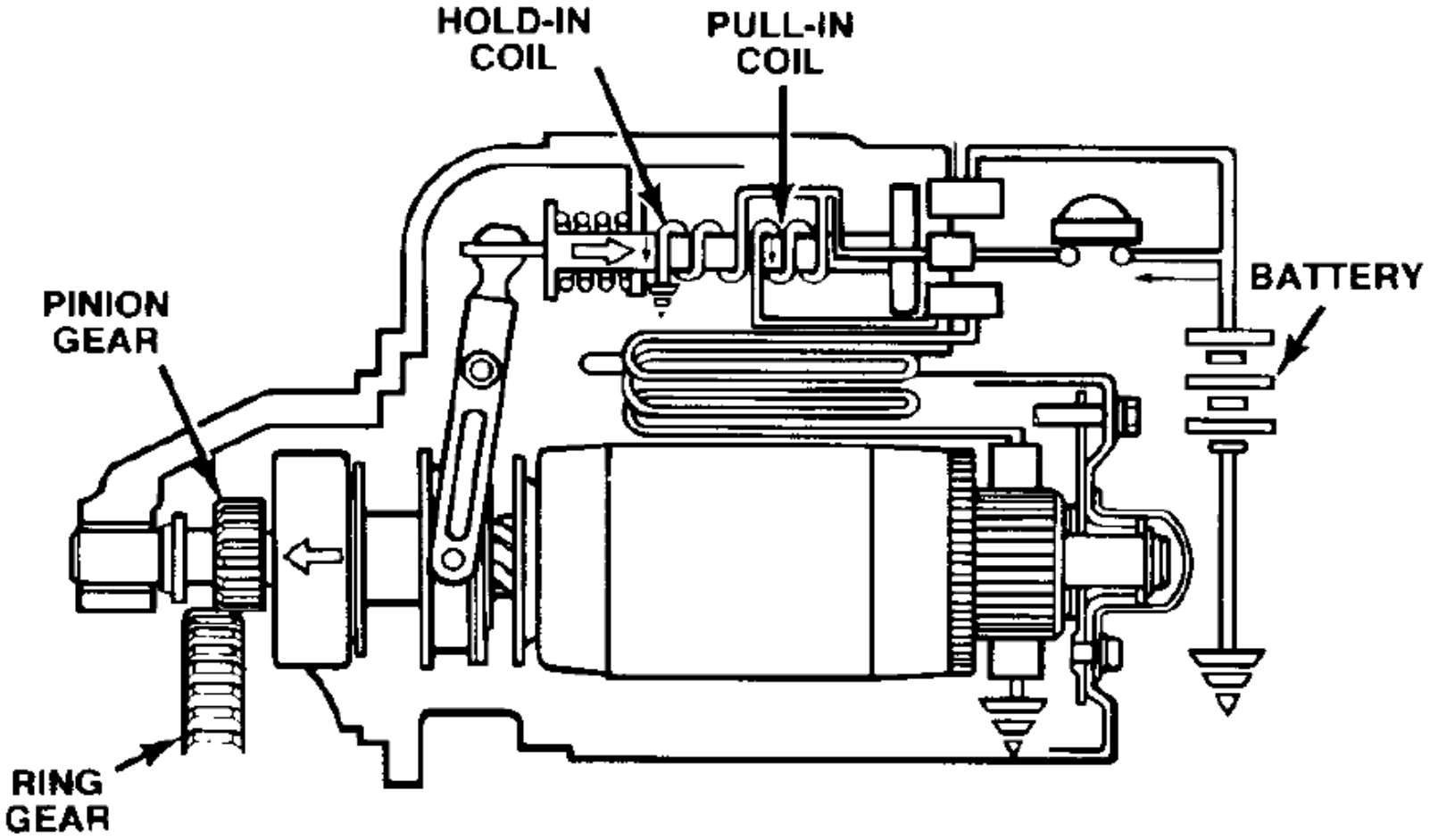


Starter motor

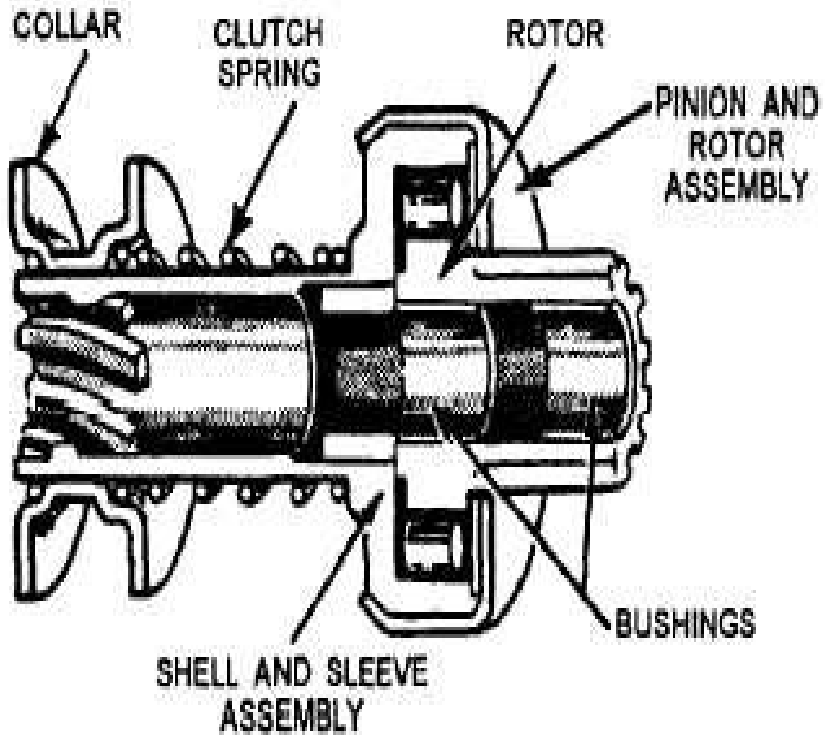


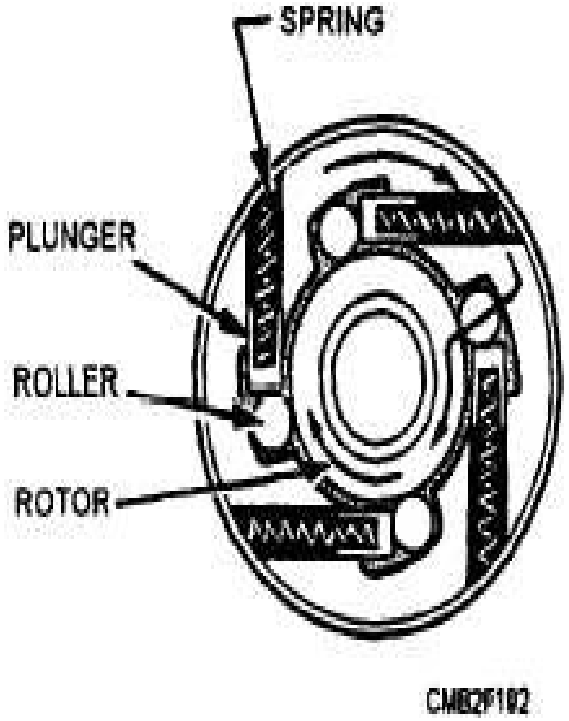
1 Drive shaft
2 Stop ring
3 Pinion
4 Roller-type overrunning clutch
5 Pinion-engaging lever
6 Solenoid switch
7 Electrical connection
8 Commutator bearing
9 Brush holder
10 Commutator
11 Armature
12 Magnet
13 Stator housing
14 Meshing spring

Starter motor operation



Over running clutch





Over running clutch-operation

Snapshot Tool