The voltage regulator also reacts to any voltage drop due to electrical loads being turned on. If you turn on the headlights of a car and draw an extra ten amps, the regulator increases the current from the alternator—it takes the additional electrical load instead of the starting battery. Both of these functions work to solve common problems associated with an automobile where the battery is only used to start the engine, but this type of regulator does little to solve the problems RVers or boaters have with deeply discharged batteries.

AUTOMOBILE REGULATORS

Automobile starting batteries are used just to start the engine and are rarely discharged by more than 5 percent of their capacity. The alternator, not the battery, provides the energy for the vehicle electrical loads while the engine is running.

Since the alternator is continuously producing current, there is a concern that the starting battery will be overcharged and outgas hydrogen and oxygen. To prevent overcharging, a regulator is needed that will supply a large amount of current initially to bring the battery voltage to a high level, but once the voltage is relatively high the current is drastically reduced. The **constant voltage** (potential) method of regulation solves this problem. A constant voltage regulator seeks to maintain output at a set voltage. If the battery voltage decreases, the charger responds by increasing output. As the battery voltage increases, the output is decreased or tapered.

Figure 5-1 Constant Voltage or Taper Chargers

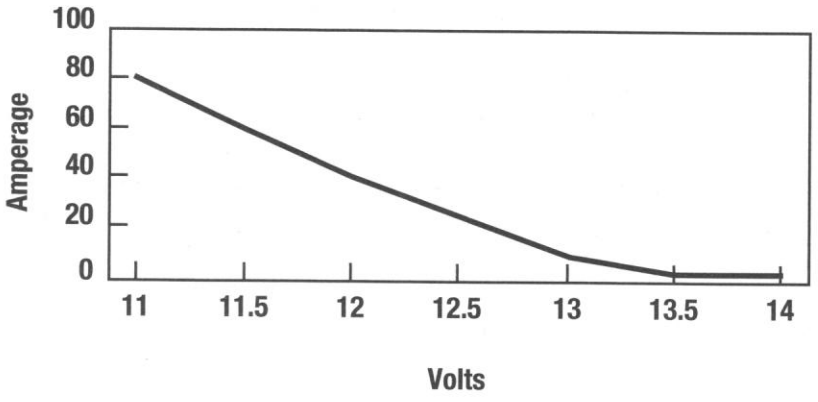


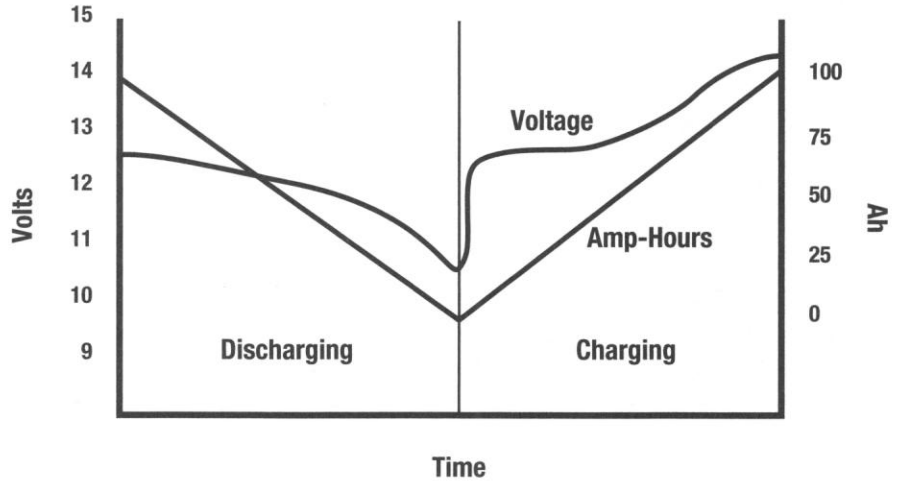
Figure 5-1 illustrates what happens when a 75 amp alternator with constant voltage regulation charges a deeply discharged battery of 11 volts. The voltage regulator is set to regulate the voltage at 14 volts. Initially the alternator produces 75 amps, but the output is quickly decreased as the battery voltage increases. At 13 volts, the 75 amp alternator output is only 10 amps, and at 14 volts, it produces 2 amps. Batteries should not be discharged to 11 volts, so 75 amps are rarely produced from the alternator. If the battery had only been discharged to 12.5 volts, the constant voltage regulator would initially produce 26 amps, decreasing rapidly as the voltage increases.

Constant voltage chargers are used mainly on systems where the batteries will not be discharged to greater than 25 percent of capacity. These systems are quite safe. They prevent the charging system, when operated over a long period, from overcharging the batteries.

THE PROBLEM WITH STANDARD AUTOMOBILE VOLTAGE REGULATORS

In figure 5-2, the left side of the graph shows how battery voltage and state of charge, as measured in amp-hours, are effected during discharge. The voltage decreases steadily until the final voltage of 10.5 volts is reached. As the battery voltage decreases, the battery's state of charge decreases linearly.

Figure 5-2 Battery Voltage and State of Charge



The right side of the graph shows that when the battery is first put on charge, a sharp rise in the battery terminal voltage occurs. This is probably due to a sudden increase in concentration of the electrolyte near the plates as the sulfuric acid is driven back into the electrolyte. Even though the voltage increases dramatically, the battery's state of charge, as measured in amp-hours, does not increase as rapidly as the voltage increases. It takes time for the sulfuric acid to diffuse to the outer reaches of the cell. During charging, the voltage does not indicate a battery's state of charge.

A standard automobile voltage regulator using constant voltage regulation senses the increase in voltage and reduces the alternator output. So fewer amps are being returned to the battery, increasing the time it takes to recharge the battery. To restore the battery's state of charge, amperage must be returned to the battery over a period of time. If you charge a battery for one hour with 20 amps, 20 amp-hours is returned to the battery. But if you charge a battery with only 5 amps, it takes 4 hours to return 20 amp-hours to the battery. (Plus an additional 20 percent must be charged because of battery inefficiency.) The higher the current the less time it takes to recharge the battery. With the decrease in amperage when using constant voltage regulation, it takes a longer time to recharge a deeply discharged battery. This is not a problem when time is of little concern. But if you want to charge a deeply discharged battery quickly, constant voltage regulation is not the answer.

Automobile constant voltage regulators solve the problem of preventing alternators from overcharging a starting battery, but will not charge a deeply discharged battery quickly.

MULTI-STAGE CHARGING

You learned earlier that a deeply discharged battery accepts a large amount of current until the gassing voltage is reached. Since a constant voltage regulator reduces the amperage well before the gassing voltage is reached, another type of regulation is needed for the first step of charging a deeply discharged battery.

A **constant current (amperage)** regulated charger produces a fixed amount of current. If the charging current is at a high setting for a deeply discharged battery, the constant current will charge the battery quickly. As the battery approaches full charge, however, the amperage must be reduced because battery damage could occur.