CAR CRAFT basics

INSIDE ALTERNATORS

A Headlong Charge Into the Inner Workings of Alternators

By Marlan Davis

During initial engine cranking, your vehicle's battery supplies the electricity needed to turn over the starter. But once the engine starts running, the **charging system** takes over to provide voltage for the vehicle's electrical systems. The basis of the charging system is a voltage-producing device known as a **generator**. There are two different types of generators: the direct-current (DC) generator and the alternating-current (AC) generator, popularly known as an **alternator**. Alternators use a spinning magnetic field to induce voltage in **windings** (stationary output conductors), rectifying the output via solid-state components (diodes). By contrast, a DC generator works like an electric motor: A stationary magnetic field induces voltage output from an **armature** spinning within the field; its output is mechanically rectified using brushes. Because the DC generator is incapable of maintaining sufficient voltage (especially at idle) to support a modern car's electrical needs, it has been supplanted by the smaller, lighter, and more dependable alternator. With DC generators practically extinct, we'll focus on alternators here.

AC Current Production

An alternator is made up of two main voltage-generating parts: the rotor and the stator. The **rotor** fits in the center of the alternator housing. It consists of field-coil windings mounted on a shaft supported by needle or ball bearings. **Brushes** and **slip rings** allow battery current to be fed into the rotor windings. This creates a magnetic field around the windings, and when a drivebelt spins a pulley mounted on one end of the rotor shaft, the entire rotor assembly turns, producing a rotating magnetic field. Two claw-shaped pole pieces, each of opposite polarity, surround the field windings and act to increase the magnetic field's strength. A **cooling fan** or fans also mount on the rotor shaft and circulate air through the unit to keep it cool. The fan(s) may be externally mounted behind the drive pulley, internally mounted inside the case, or both.

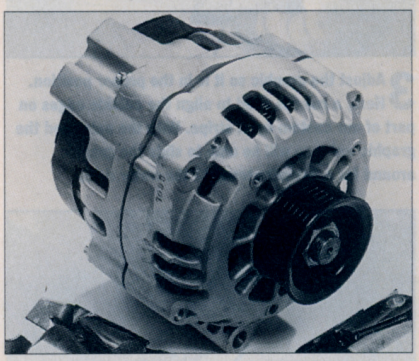
Surrounding the rotor is the **stator**, a stationary set of three output windings or loops wrapped around a soft, laminated iron frame or ring. As the rotor spins, its strong magnetic field cuts through each winding or loop in succession, inducing voltage in them. The iron frame concentrates and strengthens the field around the stator windings.

Like any magnet, the rotating magnetic field has a north and south pole; during each rotor revolution, every loop (winding) gets exposed to an alternating north-south-north polarity. This produces AC voltage, which, when connected to a circuit, causes AC current to flow. In other words, each winding in the stator repeatedly has current flowing in one direction, then the other.

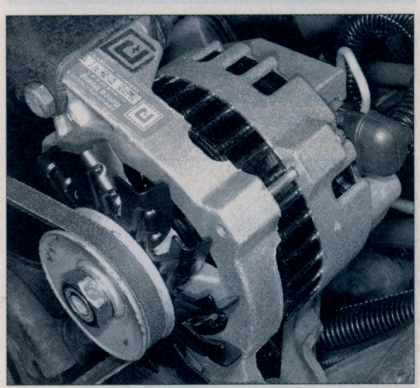
DC Current Production

AC current is bidirectional (it flows in two directions). But automotive electrical systems are designed for DC current, which flows in only one direction. Therefore, the alternator's initial AC voltage output must be **rectified** (changed) to DC voltage. What's needed is the electrical equivalent of a one-way check valve—a **diode**—which when installed on the alternator's stator output side allows current flow in only one direction.

In the real world, alternators use a set of diodes, because one diode can't capture all the alternator's output and would create a pulsing DC output instead of smooth DC current flow. The alternator's diode set—formally termed a **rectifier assembly** or **diode bridge**—commonly consists of six diodes (three positives and three negatives) that provide **full wave rectification** (they convert all of the AC from the stator into DC). Each pulse occurs so rapidly that the output seems to be a constant DC voltage. Some alternators add a **diode trio** that uses the stator output to feed current to the rotor field windings via a connection in the voltage regulator.



GM-Delphi's latest alternator development, the compact yet powerful CS-130D, dispenses with an external cooling fan in favor of two internal fans that mount inside the front and rear of the case. Ratings up to 105 amps are available.



A good retrofit candidate for classic musclecars, late-model CS-130 alternators offer significant advantages over earlier designs in both size and weight reduction, as well as increased performance at both engine idle and rated output. For conversion instructions, see CAR CRAFT, "Charging Ahead" (Nov. '93).

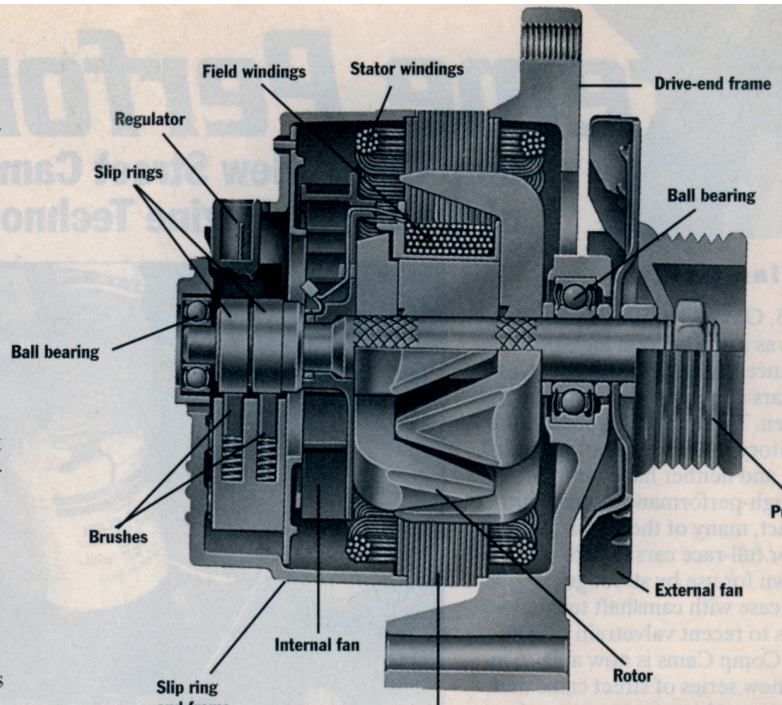
Voltage Regulator

Left to itself, alternator output voltage increases with increases in alternator speed. Since sufficient voltage must be developed at low speeds to charge the battery and operate electrical accessories, this voltage, if uncontrolled, at high alternator speeds would increase to values that would overcharge the battery and damage the accessories. Thus, a **voltage regulator** is used to control alternator voltage by changing the

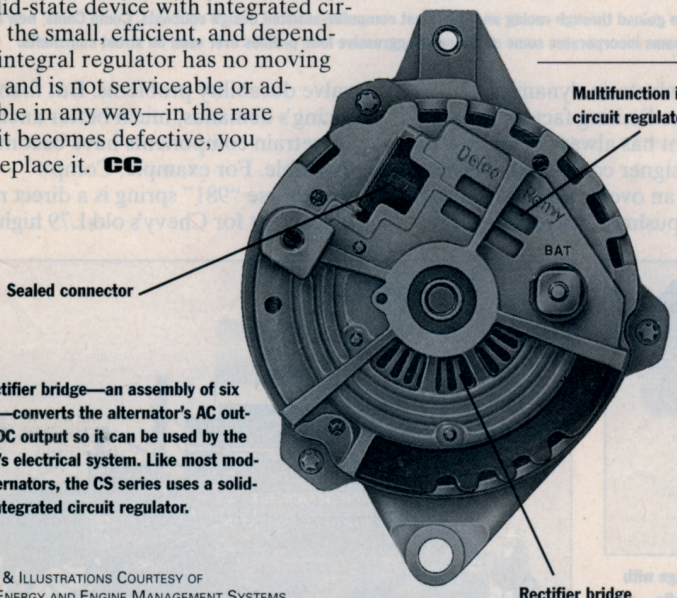
amount of current that flows through the rotor windings. To increase alternator output, the voltage regulator permits more current to flow to the rotor windings, which in turn correspondingly induces additional voltage into the stator windings and out from the alternator. To reduce alternator output, the voltage regulator reduces the current flow to the rotor windings, which in turn causes the field strength to drop and induce less voltage into the stator windings.

The voltage regulator causes the alternator to maintain a preset charging voltage. It increases or decreases current flow to the field windings based on alternator rpm, electrical-system load, and (on some designs) ambient temperature. For example, under conditions of high load or low rotor speed (engine at idle), the regulator senses a system voltage drop and increases the rotor-field current until the preset voltage is obtained.

Although first-generation alternators relied on an external engine compartment–mounted regulator, most modern alternators use a small integrally mounted electronic voltage regulator. A solid-state device with integrated circuits, the small, efficient, and dependable integral regulator has no moving parts and is not serviceable or adjustable in any way—in the rare case it becomes defective, you just replace it. **CC**



The CS-130 has permanently lubed sealed bearings. An external fan behind the pulley pulls cooling air into the unit. An internal fan mounted on the rotor pulls air through the slip-ring end frame to cool the rectifier bridge and regulator. This cutaway shows the location of many of the components discussed in the text.



The rectifier bridge—an assembly of six diodes—converts the alternator's AC output to DC output so it can be used by the vehicle's electrical system. Like most modern alternators, the CS series uses a solid-state integrated circuit regulator.

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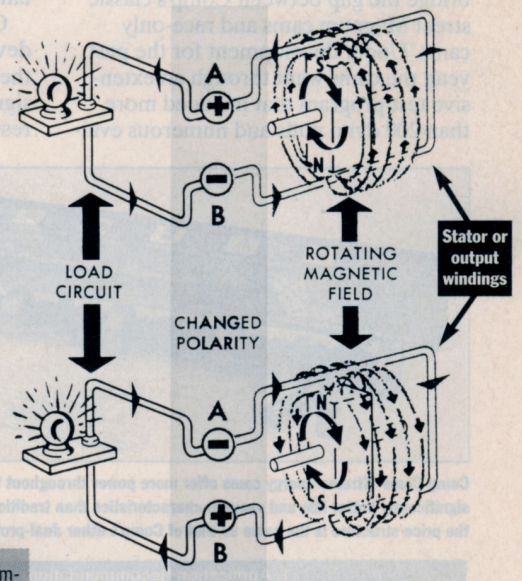

An alternator's rotating magnetic field moves across stationary windings, inducing current into the windings and out to the load. The field polarity reverses when the field moves through one-half turn, causing current flow in the opposite direction. The result is AC current. A lightbulb connected to the load would glow.

Quick Check

To test an alternator, *never* disconnect the battery while the engine is running—the resulting voltage spike is to an alternator and other sensitive electronic components such as the computer what throwing your trans into Neutral at high rpm is to your engine. Instead, use a common voltmeter to measure battery voltage while the engine is running. A good alternator will maintain the battery voltage between 13.9 and 14.8 volts (14.2 is optimum). Be sure that the engine is running at a high enough rpm for the charging system to function (especially if you're running a one-wire alternator that's excited at a specific rpm level), and keep pulley drive ratio in mind if large-diameter or underdrive drive pulleys are used.

PHOTO BY MARLAN DAVIS

Source

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