Orest Lazarowich
Presents

Looking Backward
but
Moving Forward

A Continuing Series focused on the Repair and Restoration of your old Car and Truck.

Battery and Charging Circuit

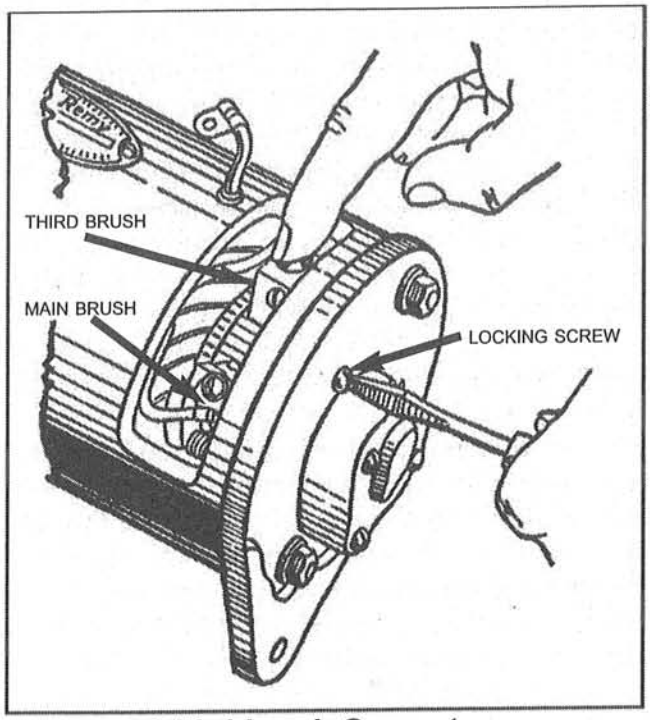
The purpose of the charging system is to maintain the charge in the vehicle's battery and to provide the main source of electrical energy while the engine is running. If the generator/alternator is not producing electrical energy, the battery will not recharge. Do a quick battery test with a multimeter. Set the scale to the 20-volt range. The multimeter should read a minimum 12.6-volts for a 12-volt battery and 6.3-volts for a 6-volt battery with the engine off. With the engine running at idle the voltage readings should be 13.8 to 14.7-volts depending on the type of 12-volt battery. A 6-volt generator should produce a voltage of 6.8 to 7.2-volts when the engine is running at greater than idle speed. Check the service manual for the correct setting of the voltage regulator on your vehicle. If the generator/alternator is producing enough voltage and current to keep the battery charged, the system is operating properly. If the battery is not holding the charge, the problem is at the battery. If the generator/alternator is not putting in enough charge, the problem is at the generator/alternator or the regulator system.

First, check for a slipping drive belt which will cause the generator/alternator to slow down (slip) and not deliver enough charge to recharge the battery. Raise the hood and prop it up, if the hood springs are weak. Check that the generator/alternator pulley turns and the bearings are not seized. Look for shiny or glazed sides on the belt where it comes in contact with the drive pulley. Adjust the belt, if it is loose, and replace the belt, if it is glazed, torn or cracked. Follow the shop manual tension specifications. If you over tighten the belt, it can cause bearing failure. Check for loose wire connections. Check the battery cables for corrosion. Corrosion will limit the amount of charge being delivered to the battery. Clean and/or replace the battery cables. Clean the battery posts. Make sure there is a good ground connection. If the battery is maintainable and has fill holes, top up the water level, and charge the battery using a battery charger. Sometimes this will extend the battery life a bit longer. If you are driving in the evening and the headlights start to dim, the problem is with the generator/alternator and not the battery. However, batteries can develop a bad cell that prevents them from taking a charge and the battery has to be replaced. Refer to page 24 in this month's *Skinned Knuckles* issue for some very important information on battery replacement.

Generator Charging Systems

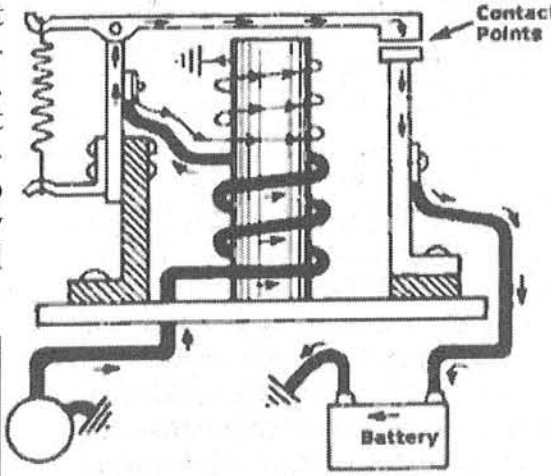
The generator has two field coil windings that produce a magnetic field when the armature rotates. As the speed increases generator output increases, and a cutout switch closes directing the electrical power to recharge the battery and operate the various accessories. During the late 1920s and early 1930s most cars, trucks and tractors used a generator fitted with three

brushes. To control the generator output, the field circuit was connected so the current sent to the field coil windings was taken off of the commutator by the third bush (field brush). This brush was placed between the two main brushes and is adjustable. The closer this brush is to the main brush, the more output the generator has, and the further away the brush is, the less output the generator will have. The third brush worked similarly to a voltage regulator. When it is moved away from the main brush the current to the field windings is reduced, and the output drops. These early vehicles had a very light electrical load and did not need a voltage regulator. If you did any night driving, the idea was that you moved the third brush 'up' to increase generator output. If you forgot to return the brush to its original setting the next morning, the battery would overcharge during daytime use and boil out the water.



Third-brush Generator

On some three brush generators, there is only one control. It is the cutout relay, which is a magnetically controlled switch. It has a single set of points and a small shunt coil inside a metal canister. The points are normally held open by a spring. When the battery is low and the engine is running, a magnetic field is created and the points close to provide a path for current flow from the generator to the battery. When the battery becomes fully charged and the generator voltage is below battery voltage a magnetic field is developed, and the points open stopping the flow of current to the battery. There were a number of problems with the cutout. Moisture would cause the points to stick together, and the battery would become overcharged. Vibration transferred from the generator would sometimes cause the cutout to lose its ground and the generator would not charge. If your vehicle uses a third brush generator, keep the points clean because over time they become 'arced'. They will stick together. In a couple of hours the battery can run down, and the points will become welded together. The cutout will have to be replaced. On others, a two-unit regulator that includes a cutout relay and a voltage regulator is used. As previously noted, the cutout relay opens and closes the generator to battery circuit. The voltage regulator is a voltage limiting device that prevents the voltage from exceeding a specified maximum and reduces generator output to the value required for the electrical load.



Schematic - Cut-Out Relay

During the late 1930s increased electrical demand from radios, twin horns, double tail-lights, heaters and directional signal lights required a generator with higher current output. The three brush generator was replaced by a two brush generator. The charging system now included a three unit regulator which is commonly called the voltage regulator that controls the voltage and current delivered to the car battery and the accessories. An ammeter, a 6/12-volt battery, wires and cables, and a ground

connection completed the charging circuit. There are two different voltage regulator designs. These are called 'A' circuit regulators and 'B' circuit regulators. To identify the type of regulator check the connections at the brushes and the field. If the generator field coil is connected to the insulated brush at the back of the generator, this is an 'A' type circuit (most GM products). If the generator field coil lead is connected to either the grounded brush inside the generator or is connected to the inside of the generator frame itself, this is a 'B' circuit (most Ford products). To check regulator output or adjust the regulator refer to the shop manual.

During the 1950s many vehicle manufacturers changed from a 6-volt system to a 12-volt system with negative ground. This became necessary because of all the new power options available: air conditioning, power windows, power seats etc. The maximum generator output is controlled by the three unit regulator. The regulator consists of a cutout relay (circuit breaker), current regulator relay (heavy gauge wire) and a voltage regulator relay (lighter gauge wire) which are all mounted on one base and enclosed by a cover. Each of these has a single set of contact points. Some regulators have a double set of points in the voltage relay because of increased electrical load of accessories. The cutout relay opens the circuit to prevent the battery from discharging whenever the engine is stopped or the generator is operating at low speed. When the voltage at the generator is greater than the battery voltage the voltage regulator relay closes and the generator supplies current to the electrical system. The current regulator relay automatically controls the maximum output of the generator. When electrical system demands are high and the battery is low the current regulator relay protects the generator from overload by limiting its output to a safe level. The voltage regulator relay limits the voltage in the charging circuit to a safe value. When the battery is low and the generator output is near maximum the voltage regulator relay limits the voltage as the battery comes up to charge, to prevent overcharging the battery.

Generator/Regulator Test

Turn off all the accessories. To test the 'A' circuit single contact regulator system, connect the multimeter leads to the battery. Negative (-) to the negative battery post and positive (+) to the positive battery post. Measure the battery voltage with the engine off. The minimum reading should be 6.3-volts for a 6-volt battery and 12.6-volts for a 12-volt battery. The voltage regulator is heat sensitive. Start the engine and let it run until it reaches operating temperature. Bring the rpm up slowly, and the voltage reading should increase. If there is no increase, eliminate the regulator. Locate a short jumper wire and clip one end to the field (F) terminal on the regulator. Connect the positive lead of the multimeter to the battery (B) terminal on the regulator and the negative lead to a good ground on the engine. Start the engine and accelerate slowly. Ground the other end of the jumper wire. If the voltage comes up 6.8 to 7.2 on a 6-volt system or 13.8 to 14.7 on a 12-volt system, the regulator needs adjustment or replacing. If there is no change in the voltage reading, repair/replace the generator. If this is a 'B' circuit generator, connect a jumper wire from the armature terminal to the field terminal of the regulator. DO NOT exceed the above voltage readings because the generator is uncontrolled and will be damaged.

Regulator Adjustments

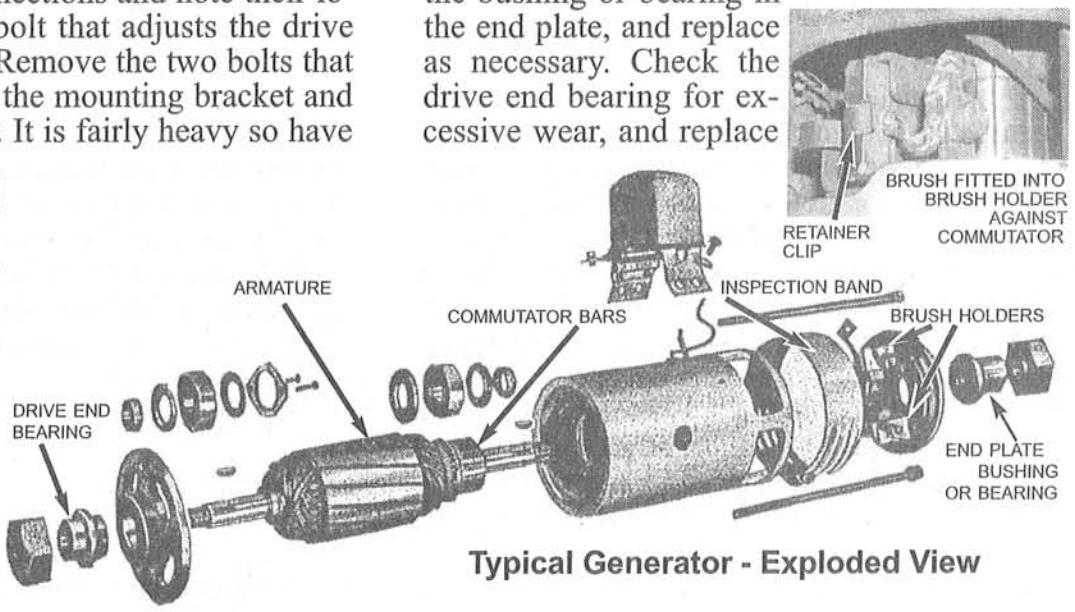
A regulator and generator in good working condition will keep the battery at the proper charge level. When you start the vehicle the ammeter needle will move to the far left (-) side of the gauge as the starter cranks the engine. As the engine starts the needle will move far right (+) and after a few minutes of driving the needle will stay just above the plus side as the generator maintains the battery charge. The voltage regulator manages the charge rate. At idle speed the needle may move to the minus side because the regular cutout has opened the generator/battery circuit. As the engine speeds up, the cutout closes and the needle is in the plus side. If the needle stays in the minus side, refer to the generator/regulator test. If you notice a continual high charging rate on the ammeter and the battery is fully charged, the problem can be a

defective voltage regular unit. Headlights that are brighter than normal or bulbs (sealed beams) that burn out prematurely or a battery that emits a rotten egg smell are signs of a battery that is being overcharged. Remove the old regulator and examine the resistors (under the base) and the coils and points under the cover. If they are burned, the voltage regulator has to be replaced and the wiring checked. The voltage regulator must be matched to the generator. Make this evident to the parts person. If the points are good, clean off any corrosion with crocus cloth. Do NOT try to remove any pits. Blow out any metal dust with compressed air. Do not disturb the springs or the point setting. Visually check all the wiring and clean the wire connections. Make sure there is a good ground connection at the firewall. Before you start the engine repolarize the generator. On a type 'A' circuit, momentarily connect a jumper lead between the regulator 'BAT' and 'GEN' terminals after all leads have been connected. On a type 'B' circuit disconnect the lead from the 'FLD' regulator terminal and momentarily touch it to the regulator 'BAT' terminal. This procedure matches the polarity for the generator and the voltage regulator by allowing a surge of current to flow through the generator Start the engine, and check the voltage output.

Generator Removal

Disconnect the battery ground strap. Disconnect the wire connections and note their location. Remove the bolt that adjusts the drive belt tension bracket. Remove the two bolts that hold the generator to the mounting bracket and remove the generator. It is fairly heavy so have a good grip on it. Take it to the bench and clean the outside. Troubleshoot why you removed the generator. If the charge was very low, the problem could be a dirty commutator or worn brushes. If it was noisy, the front bearing may need replacing. If there was no output, there could be a broken wire inside or the armature and/or field winding's are not electrically sound. Remove the inspection band or remove the two through bolts and pull the armature and drive end assembly off. Pull the commutator end plate off the generator case. Inspect the commutator inspection band and brush plate for any signs of 'thrown' solder which indicates the generator has been overheating. An odor similar to burning plastic is the usual tip-off that the varnish insulation has gotten too hot (melted) and the wiring is short-circuited.

Inspect the steel laminations on the armature. They should be shiny and not discolored from heat. Clean off any rust. Black or burnt armature windings indicate overheating. The copper bars on the commutator can be dirty, but they can be cleaned with sandpaper. If they are burned black or loose, the windings are shorted. The armature needs to be replaced. Test the field coils for continuity and grounds. Check the condition of the brushes and brush springs. A brush that is sticking or a weak spring will cause intermittent output. The contact surfaces of the brushes should be shiny, but if they are dull, the brushes have been arcing. Replace the brushes, if they are worn. Test the brush holders and the commutator end plate for continuity. One brush holder will be insulated while the other will have continuity to the brush plate. If the insulated brush has continuity, the brush plate has to be replaced. Inspect the bushing or bearing in the end plate, and replace as necessary. Check the drive end bearing for excessive wear, and replace



Typical Generator - Exploded View

as necessary. If the armature and field coils need replacing, it is wi$er to exchange the generator for a rebuilt one. Bearings and brushes can be changed out. If the armature is okay, clean the commutator bars with 00 grade flint sand paper. A 1/32" undercut on the mica is okay.

If the bearings are worn and noisy or rough turning, they must be replaced. Mark the position of the end plates to the frame with punch marks. To replace the drive end bearing remove the pulley. Check your service manual as some pulleys are pressed on while others are held by a nut. Some may be threaded on so be sure of what you are doing. Remove the Woodruff key and pull the pulley and cooling fan off. Pull the bearing and the drive end frame off the armature shaft. Remove the retaining plate on the end frame to expose the bearing. Drive the bearing out. If this is a sealed bearing, replace it. Do not grease it with a hypodermic grease gun attachment. The bearing is worn out. If this is an open bearing style and there is an oiler in the end frame, pack the new bearing with a high melting point grease to about half full. If there is no oiler pack, it almost full. The oiler type will have a felt washer under the bearing, Dip this washer in clean oil, and squeeze out any excess oil. Assemble the bearing in the end frame. Service the brush plate bearing the same way. If a bushing is used in the brush plate and the armature shows signs of hitting the field coils, the bushing is worn and must be replaced. If you cannot buy a bushing, replace the brush plate.

Replace the generator brushes and seat them to the commutator to prevent arcing. Wrap a strip of 00 grade flint sandpaper the same width as the commutator around the commutator in such a way that it will stay tight. Insert the armature into the bushing/bearing in the brush plate with the brushes against the sandpaper. Turn the armature until the brushes are shaped to the commutator. Remove the armature and the sandpaper. Blow out the carbon dust. Pull the brushes out of the brush holder far enough to jam the brush spring against the side of the brush to clear the commutator during installation. Assemble the generator end plates to the frame locating marks. Armature must turn freely. Use a wire hook to set the springs on the brushes. If you have a brush spring scale, check the spring tension (28 to 32 ounces). A mini fish scale can work. Apply the scale at the point of contact between the spring arm and the top of the brush. Read the force applied just as the arm lifts off. Try to maintain equal brush pressure. Too much pressure causes rapid wear heat build-up. Too little will allow the brushes to bounce causing burned and pitted commutator surfaces. Fit new springs, if the old ones have lost their tension. Replace the inspection cover, if used. Paint the generator shiny black. Install and road test.

Alternator Service

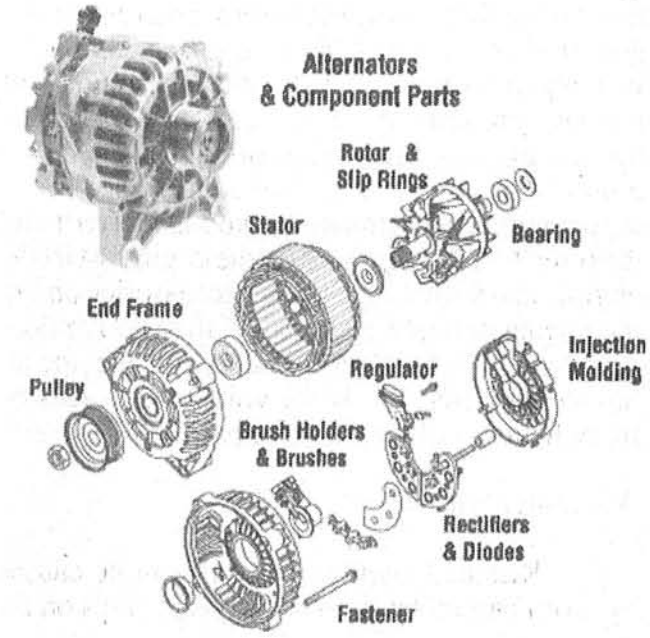
Check battery voltage with the multimeter set to the 20-volt range and the probes connected to the battery. Minimum reading should be 12.6-volts. If battery voltage is low, charge the battery using a battery charger. Check the drive belt for tension and condition. If it is too loose, it may slip on the pulley and not spin the alternator fast enough. Too tight it places a side load on the bearings and wears them out prematurely. Check that all wiring is clean and tight. Keep the probes connected at the battery. Start the engine, and increase the engine speed. All alternators have a voltage regulator which keeps the voltage between 13.8 and 14.7-volts. If the voltage does not change, check the alternator. If the voltage is higher, the alternator's voltage regulator may need replacing or the alternator is bad. If voltage is within range, turn on the lights and accessories, and run the engine at highway speed. If the voltage increases ½-volt above battery voltage, the alternator and regulator are okay. If the voltage does not increase by ½-volt, turn the engine off. Disconnect the multimeter at the battery, and connect one probe to the alternator terminal marked BAT (red) and the other to a good ground on the engine. Start the engine, and with the lights and accessories on run the engine at highway speed. If the voltage does not increase ½-volt above battery voltage, the alternator is defective. If the voltage increases by more than ½-volt, replace the regulator.

Alternator Service

Reduced alternator output can be caused by worn carbon brushes or dirty slip rings on the

rotor assembly. Brushes on some alternators are accessible from the outside of the unit without removing the alternator. Check the service manual. Reduced output can also be caused by a shorted diode. It is the diodes in the alternator that convert the alternating current (AC) to direct current (DC) so the battery can be charged. A shorted diode emits a whining sound from the alternator and will cause a dimly glowing dashboard warning light. If you hear a grinding noise coming from the front pulley area, the bearing is worn. The pulley should turn smoothly with no rough spots.

Locate the alternator on your vehicle, and prepare the necessary tools for its removal. There may be a number of V-belts that run accessory applications off the crankshaft pulley. Multi-grooved V-belts have also been used. Serpentine belts came to the automotive industry during the late 1970s. Before you disconnect the alternator wiring disconnect both battery cables. Depending on the location of the alternator you may find it easier to work from the top or the bottom of the engine. Wear your safety glasses. Disconnect all the necessary wiring from the alternator, and label them. Remove the bolt on the slotted adjusting bracket, and disconnect the necessary belts. Remove the bolt(s) that hold the alternator to the engine. Remove the alternator, and take it to the work bench. If there was no voltage output during the test, your best repair is an exchange alternator. If the test indicated that the voltage



regulator could be the problem, replace the voltage regulator. Refer to the service manual for your particular vehicle. Early style alternators use a voltage regulator mounted on the firewall or inner fender panel. Regulators used after the late 1960s are part of the alternator. There is no cutout because the diodes allow the electrical current to flow only in one direction and that is to the battery. The voltage regulator limits the maximum voltage to 13.8- to 14.7-volts in the electrical system and causes the alternator to produce more output when voltage is low. Make a note of the color of each wire connected to the terminal. To remove the regulator disconnect the wiring and take out the mounting screws. Lift out the voltage regulator. Replace the new regulator, and attach the wires to the correct terminals. Start the engine and check the voltages.

If the brushes can not be serviced from the outside, the alternator has to be disassembled. Index the housing halves so you can correctly reassemble the alternator. The housings will fit more than one way, and you will find the wires might not reach. Unscrew the through bolts, and pull the housing apart. If the front bearing does not spin freely, it should be replaced at this time. Sealed bearings should always be replaced. The rear bearing, if it is the roller type hardly ever needs replacing. A dab of grease is usually what it needs. Refer to the service manual, and locate the brush holder. Take out the mounting screws, and remove the brush assembly. Polish the slip rings with very fine sandpaper, and blow clean with compressed air. Put the new brushes in the brush holder, and find the two holes in the brush holder. Push the brushes down against their springs, and insert a wooden toothpick in the holes to keep the brushes down in the brush holder. Locate the brush holder with the mounting screws. Slide the two halves together in line with the index marks. Bolt the halves together. Remove the toothpick, and release the brushes. Install the alternator, and adjust the belts. Connect the wiring and the battery. Start the engine, and check the voltages. Happy motoring.

S.K.

Next Month:
Turn Signals and Gauges