Motorcar Tech-Talk

With Dick and Ron

Dick and Ron, **"The all-knowing Motorcar Brothers"** who are distantly connected to the Tappet brothers, Tom and Ray from Boston, will answer those tough motorcar technical questions. Please submit your questions to either:

Dick Ray
5 Hemlock Place
Randolph, NJ 07869
ray_r@rocketmail.com

Ron Zammit
469 Campana
Arroyo Grande, CA 93420
rzammit@polymail.cpunix.calpoly.edu

UNDERSTANDING ALTERNATORS-1

Joel Williams submitted our first question as to how generators and alternators work. The information for this article was supplied by Joe Porhammer of Glendale, OR who had, as additional sources, the book AUTOMOTIVE ELECTRICAL AND ELECTRONIC SYSTEMS" by James Halderman and his own experience with several MT-19's. Additional credit goes to Editor TomHull of "Quarter Inch Drive", a technical publication for the Tri-Cities, OR school district.

Before we proceed, we must understand that electrical voltage is generated when a wire loop crosses through a magnetic field. The voltage can be increased by speed of crossing, the numbers of wires, or the strength of the magnetic field. This voltage provides the current needed to operate electrical devices. First, the difference between the old, pre-1970's auto generators and the present alternators:

A) The generators had fixed field (outside) magnets surrounding rotating coils of wire. These coils, parallel to the shaft and the outside magnets, were connected to their individual commutator segments on the rotor. Carbon brushes rode on the commutator segments for transmitting all the generated electrical current to the voltage regulator and thence to the rest of the electrical system, including the battery. Some old generators could generate several thousand watts at high RPM. There is many a home-made DC arc-welder still out there using a heavy-duty automotive generator for power. The catch here is "high RPM". With the proliferation of air-conditioning and countless other electronic goodies now in cars, it was necessary to provide adequate power at idling speed. Along came the alternator, a device developed in the '30's for low RPM applications, such as Onans, tractor motors etc.

B) The alternator has no permanent magnets. It creates and rotates an electromagnetic field (rotor) inside the fixed coils around the outside (stator). Think of it as a generator turned inside out. Power is drawn directly off the fixed stator windings instead of the rotor winding and brushes. The rotor is composed of alternating-polarity electromagnets that look like large teeth in a weird jaw. Instead of permanent magnets (remember, you had to polarize your old generator which established magnetism in the generator outer case) battery power is used to generate the electrical field. There is only a single coil, wound around the rotor shaft, therefore the commutator does not have any segments, giving much longer brush life. Also, the brushes now conduct only low-power field current to energize the coil. Because of the opposing sets of electromagnets on the rotor, the alternator produces alternating current which has to be rectified for the battery, and regulated as before.

As mentioned above, alternators create their own magnetic field by energizing sets of opposing magnets on the rotor. This is done by connecting battery current through carbon brushes riding on two insulated slip rings on the rotor shaft. Output voltage increases with the magnetic field and with rpm. An alternator regulates its output voltage by changing the rotor current through a regulator. The greater the rotor current, the higher the output voltage, rpm remaining the same. This brings up a problem observed not just with cars, but too often with motor cars. An alternator has difficulty charging a seriously run-down, or worse, dead battery. There is not enough voltage to get the rotor (field) current up, therefore the output may remain below the 13 volts needed for proper charging. An alternator often so abused will have a black rotor winding. This has sold millions of batteries when they were not the problem. A depleted battery should always be first charged with a battery-charger. Of course, a fresh battery will make the charging circuit work as it should. The field current is usually between 2 to 3 amps, or 24 to 40 watts which is what it takes for your brake light (flashing or otherwise).

Let's proceed to the power side of the alternator. So far, we've supplied current to the electromagnets only, the "pump handle". Now we must supply the muscle, and that is done by your engine. As you know, the faster we rotate and the more current to the electromagnets, the more electricity we will generate. Unfortunately, here we run into a natural law that prevents the existence of perpetual motion: inductive reactance. Basically, there is rising magnetic resistance for more current generated. It is similar to trying to push like-magnetic poles together, they will repulse. Output power is generated in three stator windings located around the outer core. The three stator windings may be connected either in series, that is, one after the other, or one end of each to a common point. In a schematic, the former is drawn as a triangle (Delta wound), the latter as a "Y" or "wye". The "wye" is the more widely used, and the one we will refer to. The common-point output connection is usually stamped STA on the terminal ring and is used for indicator circuitry. The stator's three windings produce three-phase alternating current due to the design of the opposing field magnets. This current is full-wave rectified with 6 diodes, (a neat trick in electrical design) and goes to the battery.

Unlike DC generators, current regulation is virtually self-actuating because of inductive reactance affecting the

field current. However, high voltage (over 250 V) is possible and must be controlled. This is simply done by either dropping or opening the field current to the rotor winding, thereby eliminating the magnetic field. Most alternators have integral regulator/rectifier circuits in a small case but some have them mounted on an external circuit board, with the power diodes on a heat sink.

This ends the first installment on the operation of alternators.

The next issue we will continue with repair of alternators, and we also hope to have some questions from other members. So send us your questions on mechanical or equipment issues, and we'll do our best to find the answers.

Dick and *Ron*