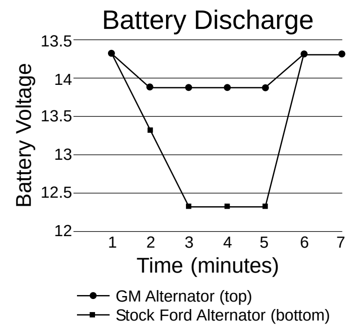
Putting GM Juice in Your Cat

Eric Overton

Recall the last time you stopped your Cat at a traffic light with the windshield wipers going, the headlights on, the blower motor on full and a turn signal on. Did the instrument panel turn signal indicator flash? I didn't think so. And the reason was that all the other items consumed so much power that there just weren't enough electrons left to trip the little underdash relay that makes the indicator flash.

And that's why you might consider swapping out your Ford alternator for one from the General—the topic of this issue's column. Ford alternators are notoriously undersized for their applications, particularly when the engine is running close to idle speed. A shot of GM juice in your Cougar offers an easy, inexpensive way to give your Cat the power FoMoCo didn't provide.

Figure 1:



Before I dug into the swap, I did a little experiment to see just how undersized my Ford alternator was; with a reasonably accurate voltmeter, you can try this, too. Connect the voltmeter to the battery, start your engine, let it idle and turn on a fair number of accessories. Then start taking voltage readings at even time intervals. If your alternator was anything like mine, you'll see a curve that looks like the "Stock Ford Alternator" curve in Figure 1. Note that it doesn't take too long to lose about 2 volts at the battery when you've got the headlights and two or three accessories on (I turned everything back off at the five minute mark to see how quickly the battery would recover).

Figure 2

To do the alternator swap, I used a kit supplied by M.A.D. Enterprises (P.O. Box 675, Springville, CA, (559) 539-7128). I performed this swap on my '68 302 car, but the same kit and procedure should apply to any Cougar model year/engine combination from '67 to '73. In hotrodding circles, putting the Delco-Remy (GM) alternator on Ford products has become a popular enough trick to provide a market for a kit with all the goodies ready-to-go, and M.A.D. did the engineering work and filled the economic niche. Figure 2 shows what you get for your $29. The materials supplied include wires, fusible links, crimp-on connectors, heat shrink tubing and a diode that *might* be required, depending on application.

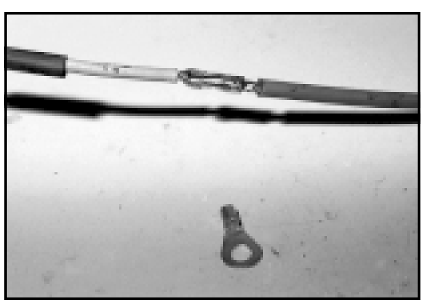


Figure 3

But before we can do the swap, we've got to make a few mechanical and wiring changes under the hood. One involves a part that *doesn't* come in the M.A.D. kit. The good news is that you can make the part yourself.

I began by making as many wiring changes as I could *outside* the car. Much of the wiring of the alternator itself occurred on my workbench. The alternator was the 63A unit originally intended for use on a '75 Camaro. I got my "Duralast" replacement alternator at Auto Zone for about $35. The AutoZone part number—it's pretty common across a bunch of auto parts stores—is 7127.

The first order of business, electrically speaking, was to connect a fusible link to the main output wire of the alternator. Fusible links are generally good ideas in circuits that can produce (or consume) large amounts of current. And an alternator is just such an animal. It's also a good idea to make the extra effort with good construction techniques when the number of amps going to or from a device goes into double digits. Here, in Figure 3, I've got a butt-splice connector crimped onto the fusible

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link, and I'm flowing solder down into the crimp. This will make a mechanically sound connection with a lot of metal-to-metal contact through which electrons can flow. In figure 4, I've put the whole splice together and am flowing a little solder into it, and in figure 5, I'm putting insulating heat shrinkable tubing over the finished joint. I used a professional heat-shrink gun, but you could just as easily heat the tubing with a match or cigarette lighter, provided you're careful enough not to set the tubing on fire. Once I'd put all of the butt-splices and lug terminals together and installed it on the alternator (while still on the bench), it looked like figure 6.

The first of the mechanical changes is to put in a larger spacer between the alternator and the engine block. The GM alternator has the same physical dimension between the pulley and the alternator case as the Ford unit. And the particulars of the pulley are the same. But the backspacing between the pulley case and the block is a lot greater on the GM piece than on the Ford. So one of the first orders of business was to machine a new spacer. Figure 7 shows the basic dimensions of the new spacer; if you want a picture that you can download and take to your machinist, you can get PDF and AutoCAD files from www.lonestar.texas.net/~eoverton/cougars/gm_alt (or by pestering me at eoverton@texas.net).

The next big mechanical difference between the GM alternator and a stock Ford unit is the size of the hole in the case for the mounting bolt that holds the unit to the block. The good news is that because the GM bolt is smaller, the hole can simply be drilled out. Before I dug in with a drill, I got out some tape and a few old plastic bags to cover any openings in the alternator case and keep the metal shavings out. I also poured a fair amount of "Marvel Mystery Oil" (my favorite cutting fluid) down the length of the drill bit in order to keep it from seizing on the relatively soft metal of the alternator case. (figure 8.)

Of course, before doing any electrical work, disconnect the battery.

In theory, removing the old Ford alternator should be easy. But this one had been in there about 10 years, and on at least one occasion a heater hose blew and dribbled coolant down onto one of the mounting bolts, where it proceeded to get scaly and rusty. So the actual removal took a propane torch, half a can of WD-40, and a really big breaker bar. (figure 10.)

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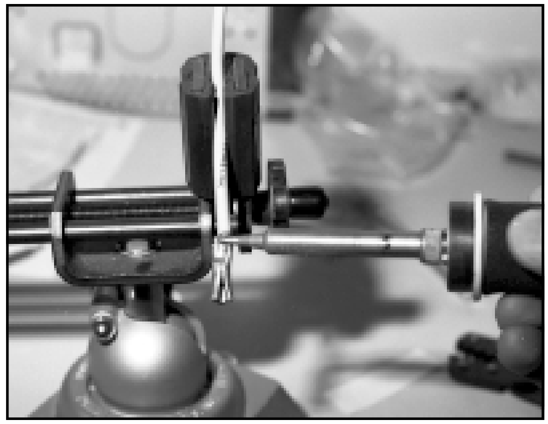


Figure 4

Figure 5

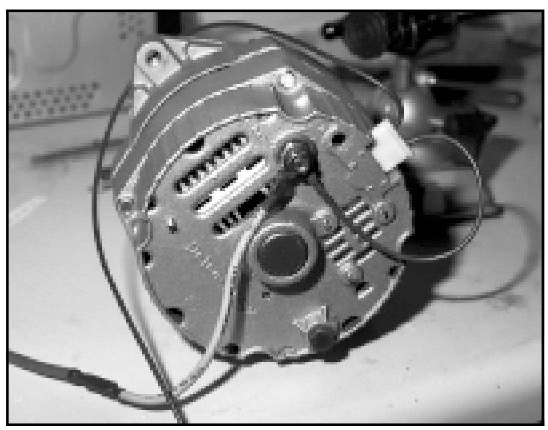
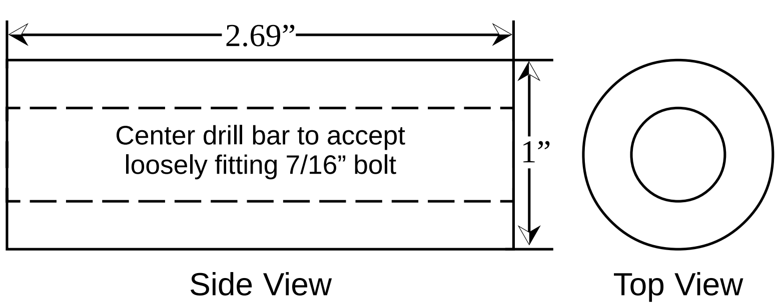


Figure 6



Material: Round bar stock of common aluminum; heat treatment not important.

Figure 7

Figure 8

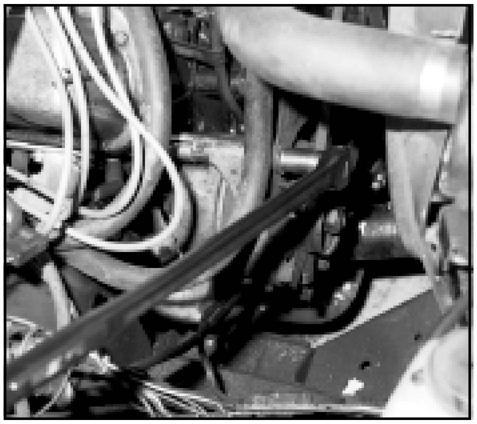


Figure 9

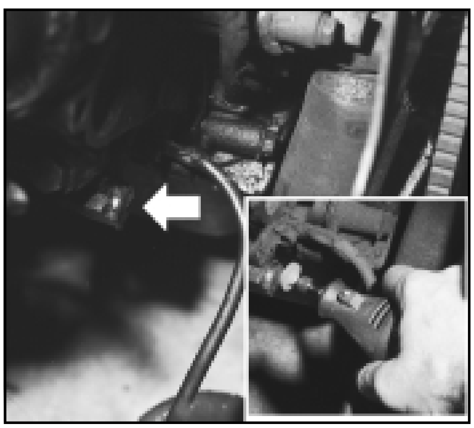


Figure 10

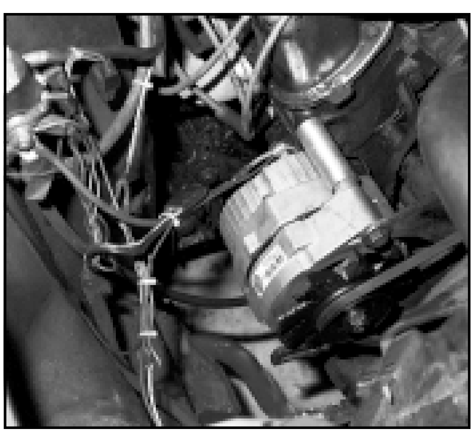


Figure 11

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While I had the old Ford alternator out and the new GM unit was yet to go in, I took a moment to lube up a tap and run it down into the mounting bolt threads in the block. I really had no intention of having to work so hard the next time I have to remove an old alternator.

After getting the old Ford unit out and the block threads cleaned up, I was ready to make a test fit. In the case of the engine here, that fit revealed that the output terminal of the GM alternator was just a little too close to the block for comfort. The problem was a result of a little extra iron "flashing" (arrow, figure 10) left over from when the block was first cast. And the solution (inset, figure 10) was pretty obvious: Load up a Dremel tool with a grinding wheel and clean that extra bit of iron back off. (Actually, the Delco-Remy alternator comes in several flavors, with the output terminals in different positions. I chose the unit here since it's the most common; had I chosen one with the terminals in different locations, I might have spared myself the trouble of doing this grinding.)

Figures 11 shows the whole enchilada once it's installed and wired. Because the GM unit is an "internal regulator" design, the total amount of wire that comes and goes to it is a lot lower than with the stock Ford unit. In fact, there are really only two wires that come off the GM alternator. One is the heavier gauge wire (to which we earlier attached the fusible link) that carries the charge to the battery. And the other is a low-current, light gauge wire that goes back to either the dashboard warning light or ammeter. Depending on how your instrument cluster is constructed, you may or may not need a diode in series in the "indicator" line. M.A.D. provides an appropriate diode in their kit and enough instructions to let you know whether you need it—and how to put it in if you do.

Because the stock Ford regulator is now superfluous, we remove it completely. And while it's on the bench, we size up a few of the spade terminals, as one of the mating connectors left behind by the regulator's removal will actually be where we connect that warning light/ammeter wire coming off the new GM alternator. A carefully selected spade lug and a little heat shrinkable tubing (as shown in figure 12) makes the warning light/ammeter circuit connector complete.

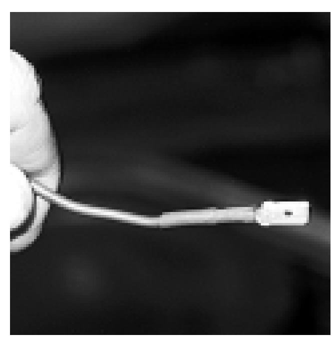

Figure 12

Once it was all installed, I redid the "battery discharge" test I performed on the Ford unit, and I got the "GM" curve shown back in figure 1.

Now that we've covered all the practical issues related to this alternator swap, we'll have a look at what

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might make one alternator more effective than another and why testing an alternator by disconnecting the positive battery cable with the engine running is a *very* bad idea—even though I'm sure your grandpa taught you to do it that way.

The GM alternator cranks out more juice than the stock Ford unit for two reasons. First, the regulator is internal, so there's a fair amount of loss in the alternator-to-regulator wiring that doesn't take place. Remember that in the Cougar the alternator is mounted on the passenger side of the engine, and the regulator is clear on the other side of the engine bay behind the driver's side headlights. That's a lot of copper through which the electrons have got to travel.

Second—and this is probably a lot more important—the GM unit is wound differently. In fact, the number of magnetic fields through which the rotating innards of the alternator pass is twice that of the Ford unit. Note that alternators can be wound all sorts of ways internally and the number of fields you interrupt (and how strong each one is) will determine for any given engine speed how much current the alternator is going to put out.

This point is worth keeping in mind, as lots of folks incorrectly size alternators for an application based on their maximum output. If I design an alternator with a lot of weak fields but spin it fast enough, I can probably get a lot of current out of it. On the other hand, if it isn't spinning fast enough, I'm not going to interrupt enough of these fields in a given amount of time, and I'm not going to get a lot of current out of it. (Recall that current is a measure of charges per second moving in a circuit.) So I may have an alternator with a truly spectacular maximum output rating that performs dreadfully at idle. In much the same way as engines have "torque vs. speed" curves, alternators have characteristic "speed vs. current output" curves; and you've got to make sure that you've got an alternator that fits your anticipated engine operating speed range and that you've sized your pulleys to gear everything effectively. The GM alternator I've swapped in here has a "speed vs. current" that works very well with the stock Ford pulleys. And it performs particularly well in precisely that r.p.m. range where the Ford unit doesn't — namely, idle and normal street driving RPMs.

That having been said, we can also say a few things about those magical coils inside an alternator that make all this mechanical-to-electrical energy conversion possible.

When we talked about capacitors last time, I mentioned the term "energy storage element," and I noted that a capacitor stored energy by piling charges on a metal plate where they could be used some time later. I also pointed out that since charges were put on and removed from the plates at different times, our description of a capacitor's "impedance" according to Ohm's Law was:

$V = 1/(Cs)\ i$

Inductors (like your ignition coil or the coils in your alternator that generate and take electrical energy from magnetic fields) are another type of energy storage element. Unlike capacitors, however, they don't store their energy by piling charges up anywhere. Instead they create a magnetic field in which they can store energy. When the magnetic field changes due to some external influence, some of the energy used to cause the change comes back out in the inductor's electrical terminals.

The thing that makes inductors particularly useful from an electrical sense is that in several key respects they behave exactly oppositely from capacitors. For example, it takes time to move energy back and forth between two media. (Remember that you're converting electrical energy to magnetic energy and back again.) And there are speed limits on just how quickly you can do this. Inductors don't like to be pushed around; and the more coils they have (with which they generate or take energy from magnetic fields), the less they like to be pushed. Thus the faster you push them, the more they're going to resist you. And as a consequence, their resistance goes up with frequency. In the case of an inductor, Ohm's law looks like:

$V = Lsi$

Note that the "frequency" term "s" (as discussed in our last installment of this series) is now in the *numerator* of our equation, whereas for a capacitor it was in the *denominator.*

This is why your ignition coil makes sparks (and why a capacitor is used to suppress these sparks at your points to keep them from burning). In the coil are inductors that exchange their energies through a magnetic field. When your points open, current flowing in one of the inductors changes instantaneously, since all of a sudden current flow goes from whatever it was when the points were open back down to zero, since the circuit has been interrupted. The definition of "instantaneously" here is "happens in almost zero time." And we know from the last installment that time and frequency are inverses of each other. So something that happens in almost zero time happens exceedingly fast—or with high frequency. Thus, the very large "s" term in the above equation causes the relatively minor change in current flow "i" to get amplified to a huge voltage. And this huge voltage is what causes a spark to be thrown at the plug.

In practice, the two inductors in an ignition coil are coupled to each other by the magnetic

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field of one inductor passing through the wound coils of wire that make up the other inductor. And since one of the two coils of wire has a great many more circular loops in it than the other, the effect of the change in current in the "primary" coil gets amplified quite a bit by the ratio of the number of "turns" of wire in one inductor versus the other. (Thus we get the term "turns ratio" when we talk about coils and transformers.) But it's important to remember that any time you instantaneously try to do anything with the current flowing in an inductor, it's going to complain about it. And the way in which an inductor complains is by generating a large voltage spike or spark.

This is why testing an alternator by disconnecting the positive battery cable while the engine is running is a really bad idea. What you're doing when you do this is instantaneously asking the alternator to change the amount of current it's supplying (since we're assuming here that it's charging the battery at least a little — and probably a lot if the battery is low from having been connected to a bad alternator.) And the inductors in the alternator see an instantaneous change in current (meaning a very big value for "s") as a good reason to momentarily throw off a very high voltage as a way of registering their displeasure. Back in the days when there weren't many sophisticated electronic devices on a car, what there was in the electrical system was pretty tolerant of getting hit with sudden shots of high voltage. So when grandpa tested the generator in his Model T using the "disconnect the battery wire" trick, he usually got away with it. But these days, things like "engine computers" tend to resent getting whacked with big voltage spikes. And even things like vintage Cougars have been retrofitted with sophisticated aftermarket electronic ignition systems that aren't going to take kindly to getting hit with the few thousand volts that a sudden alternator disconnection can throw off. So not all of Grandpa's old tricks work in this day and age.

Summing Up

Aside from getting a look at how to swap a GM alternator onto a Ford engine, this issue we got a little bit of a look into the subject of inductors (and alternators are full of inductors). We learned that alternators have characteristic "current output versus speed" curves, and that simply going for the alternator with the maximum output may not get you the current output you want at idle. Bigger is not always better. Furthermore, we learned that inductors store energy by sloshing it back and forth between moving electrons and changing magnetic fields.

We also learned that inductors follow an impedance formula that in many ways is the reverse of the capacitor formula. And we learned that as a consequence, suddenly changing the current flow in an inductor (by disconnecting a battery cable while the engine is running, for example) is a very bad idea.

Next Time

Next time around we're going to dig in on the subject of suspensions. But we'll get there by taking our equations for capacitors and inductors and realizing that masses and springs also store energy (and believe it or not, we'll build a model for a suspension system by looking at how a crystal radio works). We'll learn that masses store energy in much the way (at least in mathematical terms) as capacitors. And inductors store energy just as a spring would. Finally, the mechanical equation for a shock absorber looks suspiciously like the one for a simple resistor.

Next time we're going to draw the "circuit diagram" for a suspension and see what happens when you change your spring rates or shock absorbers. And when we start suspension tuning, what we do will be a whole lot less "hit-or-miss" as a result.