DRAWING BOARD

More on automotive voltage regulators.

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Once again I have to apologize to everyone out there who's waiting for us to get back to the design of a digital scope. We won't be doing that until next time because I need this space to finish going through our discussion of generators, alternators, voltage regulators, and all the rest of the stuff you meet when you take a trip to the always amazing world of charging systems.

As I mentioned last time, I was amazed by the amount of interest in this and, as a certified member in good standing of the old car and bike freak club (with a particular emphasis on British stuff), my duty is clear.

We've already gone through the basics of the charging system and seen that there are really only two ways an alternator can be wired into a bike or car. One side of the field winding is tied to either the hot side of the battery (a pulled-up field), or to ground (a grounded field). Most British cars and bikes use a pulled-up field and you'll find a lot of American cars using a grounded field. I said this last time but it's really important so let me repeat it. Before you can build your own voltage regulator, you HAVE to know how your alternator is wired. Using the wrong regulator will destroy the regulator and probably trash the alternator as well.

The easiest way to tell what system is used in your car or bike is to use a multimeter. With the ignition turned on, but the engine not running, measure the voltage from the hot side of the battery to the terminal marked "F" on your existing regulator. If you get a reading between 12 and 13 volts (the battery voltage), your car is using a pulled-up field.

If you get a zero, or near-zero reading, you're probably looking at a grounded field. You can make sure by reading the voltage from the regulator's "F" terminal to ground. You should see the 12- to 13-volt battery voltage there. If you don't see the battery voltage anywhere you either have a bad connection or you're measuring from the wrong terminals. Check the multimeter leads and, if that doesn't cure the problem, get out a flashlight and trace the wires. You absolutely have to know what you're dealing with before you add a voltage regulator!

Anyone who finds that they have a pulled-up field can stop reading right now and skip ahead a bit because the regulator we designed last month is exactly the one needed. If you've got a grounded-field alternator, there's still some work to do. The regulator we designed has to be modified before you can use it.

The easiest way to see the changes is to compare the original pulled-up field circuit (last month's Fig. 3) to the modified design for a grounded-field regulator shown in Fig. 1. One of the first things you should notice is that R7 and R8 are now in parallel. Electrically, there's no real reason for having those two resistors in parallel. The only reason I left them both there is to help make the similarity between the two circuits more evident. You can leave them wired in parallel or simply do the arithmetic necessary to come up with an equivalent single-resistor replacement.

The major change to the circuit is that the alternator field connection is now made off the emitter of Q3 rather than the collector. All the changes in the circuit are aimed at varying the voltage at Q3's emitter. The Darlington pair made from Q2 and Q3 is still controlled by the voltage at the collector of Q1 in exactly the same way as it is for the pulled-up field regulator. The positive feedback (supplied by C3 and R8) that speeds up the switching of the circuit from fully on to fully off now comes from Q3's emitter rather than its collector.

The reasons for the changes in the circuit are all based around the idea of being able to vary the output voltage. Since, in the case of a grounded field, the given is that one side of the field is tied to ground, the job of the regulator is to increase the output voltage at the "F" terminal when the control voltage at the base of Q1 falls below the point set by R10. The LED has been moved so it will monitor the field voltage and D1 has been moved so it can soak up any back-voltage generated when the alternator field collapses. You'll also see that the value of R7

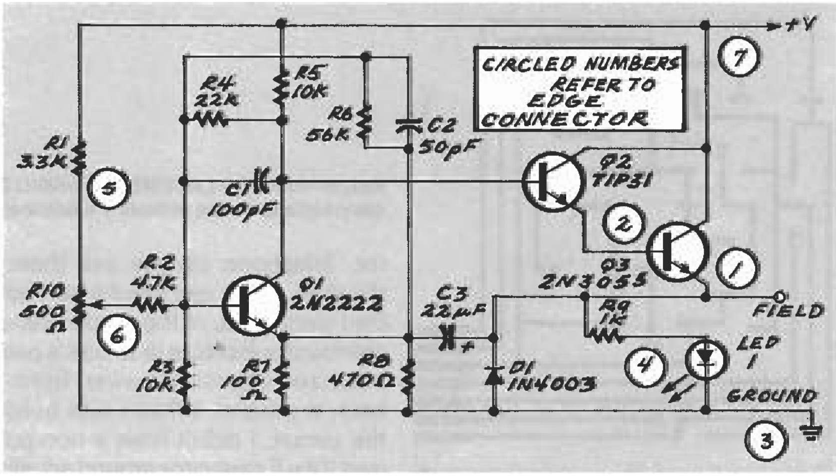

FIG. 1—COMPARE THE ORIGINAL pulled-up field circuit (last month's Fig. 3) to the modified design for a grounded-field regulator shown here.

has been dropped to 100 ohms but, as I said earlier, you can replace it and R8 with a single resistor.

Before we take this any further, a word or two has to be said about C3. When the voltage on the output side of the regulator changes, some voltage is bled off through C3 and used to help speed up the action of the regulator. That is true both when the regulator is supplying current to the alternator field and when it's shutting the field current down as well. So, when the regulator is working, current will flow back and forth through C3.

Whenever you have that situation with an electrolytic, the right component to use is a non-polarized capacitor. Telephone circuits use them all the time. If you can't find a non-polarized electrolytic of the proper value, a standard substitute is to use a pair of polarized capacitors wired front-to-back in parallel. When I was building the circuit, I didn't have a non-polarized 22 µF capacitor around so, since I was in a hurry to get the circuit in my car, I just used a regular polarized capacitor instead. Once the car was back on the road, I figured I'd be able to drive to the parts supplier, get the right component, and make the correct substitution.

That was several years ago and, even though I've made many trips to Capacitors-R-Us since then, I've never replaced the original polarized capacitor. I know it's the right thing to do

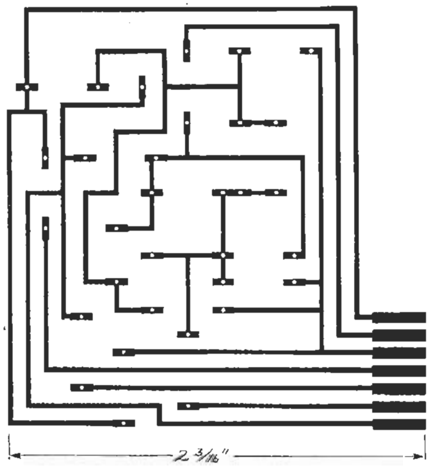

FIG. 2—FOIL PATTERN for the grounded-field regulator.

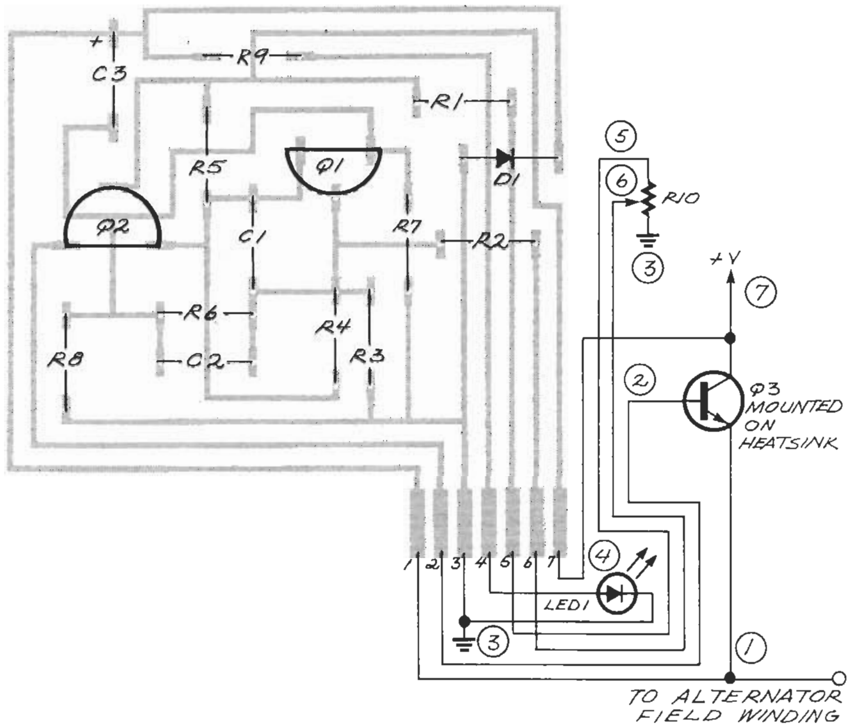

FIG. 3—PARTS-PLACEMENT/WIRING DIAGRAM. Use at least 14-gauge wire for the three connections to the vehicle's electrical system.

but I've never gotten around to it. The choice is yours.

The foil pattern for the grounded-field regulator is in Fig. 2, and the parts-placement/wiring diagram is shown in Fig. 3. If you have last month's column around, you'll see that the new pattern is not very different from the pattern for the previous regulator.

Once you have the regulator ready to install in your car, use at least 14-gauge wire for the three connections to the vehicle's electrical system. Remember that the field windings in the alternator have an impedance of only about four ohms so, with a minimum of twelve volts from the battery, the wire has to carry at least four amps. If you have any doubts about the gauge of the wire, use the same stuff that was there originally.

The only other precaution to take when you're using either one of the two regulators is to realize that, since they're designed to be adjustable, they're capable of making the alternator put out a lot of power. While that isn't so bad for short periods of time, having the electrical system run at a constant level of sixteen or seventeen volts is a good way to blow stuff up.

As soon as you have the circuit connected and you're sure that the whole charging system is working, spend a little bit of time with your multimeter to calibrate the potentiometer (R10). Adjusting the potentiometer will change the trip point of the regulator and you should have those voltages marked wherever you have the potentiometer mounted. Red-line the settings at sixteen volts—you never, NEVER want the system voltage to get beyond that point.

If you're one of those unfortunate people who have a generator as your system's electrical engine, none of the circuits we've developed are suitable. As we discussed last month, since the amount of current you get from a generator is solely dependent on how fast it's turning, the only way to control the current being fed to the electrical system is to have a make-and-break type switch between the generator's output and the rest of the electrical system.

You can always use an alternator/regulator combination in place of a generator. The only problems you'll have are mechanical ones, since you'll more than likely have to fabricate your own mounting brackets and you may be forced to do a bit of surgery to make everything fit in securely. While doing a substitution like this is simple in theory, in practice there are a couple of nasty things that can screw you up if you're not careful.

The two big hassles are the substitute alternator's maximum current output for a given RPM and the size of the alternator pulley. As your starting point, you want the alternator to be able to generate enough current when the engine is idling. I can't give you exact figures since they'll depend on your vehicle. You might be able to get them from the paperwork covering your existing generator.

Once you have a ballpark current figure, you're ready to start the search for a suitable alternator. Most alternator pulleys are about half the diameter of the main one driven by the engine. That means the alternator generally turns twice as fast as the engine and the alternator you need should have a high enough maximum current output at about twice your engine idle speed. The voltage regulator will take care of determining how much below that maximum current is right for your system. All you'll have to do is put a multimeter across the battery and adjust R10.

What makes everything complicated is the fan belt. You want to be absolutely sure that, once you have the new alternator mounted next to the engine, you can use a standard-size fan belt. This is such a big deal that I'd remake the alternator mounts to change the circumference of the needed fan belt. Nothing is worse than not being able to get replacement fan belts from any auto supplier in the universe.

I wish I had a simpler answer to the problem of generators but all I've ever done is replace them with alternators. I'll admit that it's a lot more work than building a replacement regulator but the ultimate outcome is a lot better. **R-E**