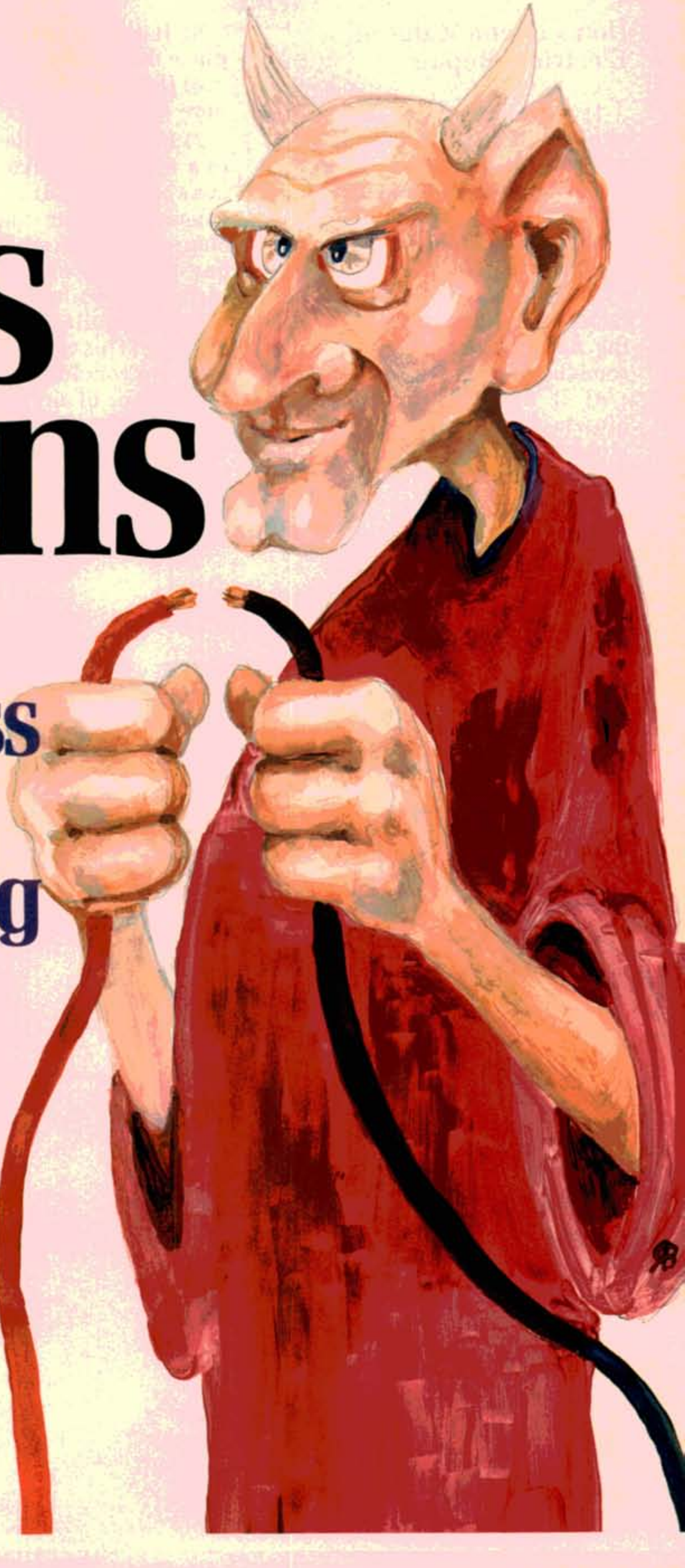
Don's Demons

A Logical Thought Process For Electrical Troubleshooting



Dyno Don was the used car man in a dealership where I worked as a line tech. He was a meat and potatoes fixer-upper who specialized in taking the rough edges off trade-ins. Brakes, exhaust, spark plugs, and other assorted bolt-on items were his specialties.

Electrical problems were a different story.

Don's opinions about electrical repairs closely paralleled his contempt for the mysteries of the electron itself. He had a list of rules about electrical problems, and a few standard fixes which he applied to all electrical problems.

Don's Demons

Don's Dozen Rules of Electrical Repair

1) All electrical problems are caused by evil demons. (Don never believed in the "trapped smoke" theory adored by many DIYers.)

2) If a fuse blows, install a bigger one.

3) If the bigger fuse blows, attach battery jumper cables across the fuse terminals and wait for something to smoke.

4) If none of the fuses are blown, but something doesn't work, replace the part that doesn't work.

5) If the car won't crank, replace the battery.

6) If the car won't crank with a new battery, replace the starter.

7) If the new battery goes dead in a few days, make up some excuse about radiation damage caused by solar flares, and recharge the battery. If they don't buy the story about solar flares, install a new alternator.

8) Wiring diagrams are a waste of time. (This often lead to Don's next two conclusions.)

9) Repair of any shorted circuit or intermittent failure requires complete disassembly of the vehicle.

10) The only way to find a short is to cut the entire main harness apart and visually inspect each wire. Retaping the harness only traps the evil demons inside where they can cause more trouble.

11) It is impossible to fix one electrical problem without creating another. You may evict the demon, but he'll only move to another part of the same car.

12) If God had wanted mortal humans to fix electrical problems, he wouldn't have made electrons invisible.

So much for Don's theories. Let's see if we can't establish a more logical thought process for troubleshooting electrical problems. You'll notice that we don't even mention oscilloscopes in this article. We'll even tie one arm behind our back, so to speak, and save the simplest voltage tests until we've eliminated the obvious. What we're concerned with here is the thought process which can lead us toward a solution of our problem.

Don and his demons will drop in throughout the article to show us how not to fix electrical problems.

Rule One—Verify the Complaint

Getting the whole truth from a customer can be likened to extracting pure gold from styrofoam cups. As masters of oversimplification, many customers will do their best to hold back important information as though any relevant facts were earning 10 percent interest.

If you've ever struggled for two hours with a no start, because a home installed, or alarm system controlled kill switch kept the car from running, you know why they call it a "kill" switch.

And then there's the old standby, usually scribbled on the back of an envelope in your night drop—"My car won't start."

Does that mean that the starter won't turn the engine over?

Does that mean that the starter works but the engine fails to start?

"My car won't start" has also been used to describe an empty fuel tank, efforts to start a car with the gear selector in the Drive position, or even one recorded attempt to start a car with a garage door key.

The customer is often the biggest obstacle to a speedy repair.

This bring us to Rule Two.

Rule Two—Don't Fix It If It Ain't Broke

Vehicle owners have two other endearing little tricks up their sleeves which can create an impossible repair situation. That's because we go off and try to fix something that doesn't need to be fixed in the first place.

1) In many instances, customers don't know how to operate the vehicle.

This is totally believable since it now takes a dozen MIT valedictorians to remember the 34 easy steps required to reset a digital clock. My mother is a prime example. During the months when we experience daylight saving's time, she is exactly one hour late for every appointment since she can't remember how to turn the clock ahead. As a result, she never schedules anything important between April and October.

Add in burglar alarms, trip computers, and theft proof radios which commit electronic suicide when you don't enter the secret password in the first three tries, and it's no wonder people get confused.

2) They are instructed from early childhood to assume that all gauges and warning lights are programmed to lie.

If a car overheats, the gauge is bad. If the oil light comes on, it's got to be a short. Most customers would rather repair a shorted wire than purchase a new radiator or cooling fan. And red lights are a lot cheaper than oil pumps and main bearings.

In either case, we need to talk to the customer and get the whole story before we waste our time trying to guess our way to the real problem.

Rule Three—Know the Vehicle's History

Whenever Don's current nightmare spilled over into my bay, the first thing I checked was the last thing he'd worked on. That's because I understood the intensity with which he believed in his own rule number 11 (the one about not being able to fix one problem without making another). He liked to keep the demons moving.

If he removed a tail lamp assembly to replace a power antenna, the resulting short circuit was sure to be found in one or both of those circuits. If he replaced an illumination bulb in the console, the resulting no start condition was undoubtedly caused by a disconnected neutral safety switch wire. With Don it was just a matter of vehicle geography.

And we've all been guilty. Just a few weeks ago, an associate lent us his Volvo for some tests. At one point we removed the right kick panel to get at the ECU, and in the process of concentrating on the ECU, a stray wrist or elbow dislodged the main ground wire for the heater blower motor. Unfortunately, we didn't notice it dangling in midair, and the darned electrons simply refused to jump the gap.

When Big Al told me his air conditioner didn't blow cold air, an alarm buzzer went off in the attic part of my body. I went straight to the suspected scene of the crime—the last place we'd worked. Sure enough, there was a fat ground wire waving in the breeze. While Don's rule isn't always true, the last repair is very often a good place to look for the current problem.

Rule Four—Eliminate the Obvious

One of my favorite memories of Don has to do with his attempts to repair the brake lights on a used truck. The truck was traded in by a farmer, and the distinctive aroma of manure filled the shop. No surprise since the bed and underside of the truck were coated with it.

But one of the lot attendants had already scrubbed the inside of the cab. That was enough for Don. He decided that the problem was on the clean end of the truck, and was determined to find it there. He spent the next hour or so under the dash, fiddling with fuses and the brake light switch. Every five minutes or so he would yell, "Are they on yet?"

Of course they weren't on yet! Not with two burned out brake light bulbs at the other—the dirty end—of the truck.

Rule Five—Keep Your Eyes Open

Look the car over, keeping your eyes peeled for the obvious. Low battery water, a loose alternator belt, loose or corroded battery terminal ends and cables.

Peel back the rubber boots which supposedly protect connectors, especially if the engine was steam cleaned recently. Check to see if the wire clips on connectors are in place, and that both the connector and clip are both fully locked in place.

Unplug a few things and check for corrosion. Recently, during our BMW 5-series article, I found that one of the plug wire ends at the distributor cap was badly corroded. The wire end wasn't permanently damaged, and a good cleaning with a thin wire brush corrected the occasional miss on that cylinder.

If the engine or transmission has been removed recently, check all the ground connections, especially those little ones hidden at the rear of cylinder heads, to make sure they've been replaced.

If you see a pattern developing here, that's good. What we're looking for is cause and effect, and there's a lot to be done before we ever hook up a tester.

Rule Six—Understand How the Circuit Works

Don wandered over one day carrying an entire main harness from a vehicle. It looked like the part of the buffalo you don't eat. He turned it in his hands as if trying to impart some special healing technique. As he drew nearer he pointed to a fat red wire and asked, "Does this one look like the wire for the lights?" (If he had a specialty in the electrical department it was surely the lights—brake lights, tail lights, any old kind of light.)

Since wirings diagrams would have been as useful to Don in Chinese as they were in English, he had no idea how to trace the path of a circuit without physically seeing where a wire ended up. And since he had no idea how the circuit worked—or was supposed to work—he had no choice but to track the wire. This procedure also involved some of the most incredible vehicle disassembly procedures known to man. The main tools being a large screwdriver and an even larger bar for those hard to remove plastic panels.

My request that he reassemble the car brought a look of mild disbelief, but he tacked her back together after a fashion. Then he pointed defiantly at a fuse which blew like an M80 every time the light switch was turned to the parking light position.

• The wiring diagram showed us that one main connector near the fuse panel fed the following: tail lights, license plate lights, front parking lights, dash illumination lights, and side marker lights.

We disconnected it and turned on the light switch. The fuse didn't blow. Now we knew that the short wasn't in the switch or in the dash wiring leading to the carside plug.

• Next, the wiring diagram showed us that there was a subcircuit connector beneath the vehicle. This connector fed the tail and license plate lights. We reconnected the main plug by the fuse block and disconnected the subcircuit connector. That way we could isolate the front and rear lighting circuits. Once again we turned the light switch to the park light position. This time, the front and rear markers, dash lights, and the front parking lights all illuminated.

• At this point, we had isolated our short to one tiny circuit feeding four bulbs. A glance at one of the tail lamp lenses showed droplets of condensation on the inside of the plastic. (This also falls under the category of keeping your eyes open.) I popped out the bulb and socket for that side. Bingo. The bulb was so corroded in its socket that we couldn't remove it. I soldered in a new socket and replaced the bulb, reconnected the subcircuit connector and turned on the lights. Everything worked.

In 10 minutes, without so much as a test light, we had located and repaired a dead short. Don was visibly moved. So much so, that later that day he approached me with a small relay in his hand. He was shaking it and holding it up close to his ear.

"Does this relay sound funny to you?" he asked.

Rapid Relay Checker

The reason Don asked if the relay "sounded" funny was that he had absolutely no idea how a relay or a relay circuit worked. Years before, as an inexperienced young apprentice, I had asked the wise old man of the shop an equally stupid question about a relay. Long on knowledge but short on patience, he literally dragged me to the parts window where he retrieved a relay, the appropriate relay socket, some wire, and a handful of terminal ends.

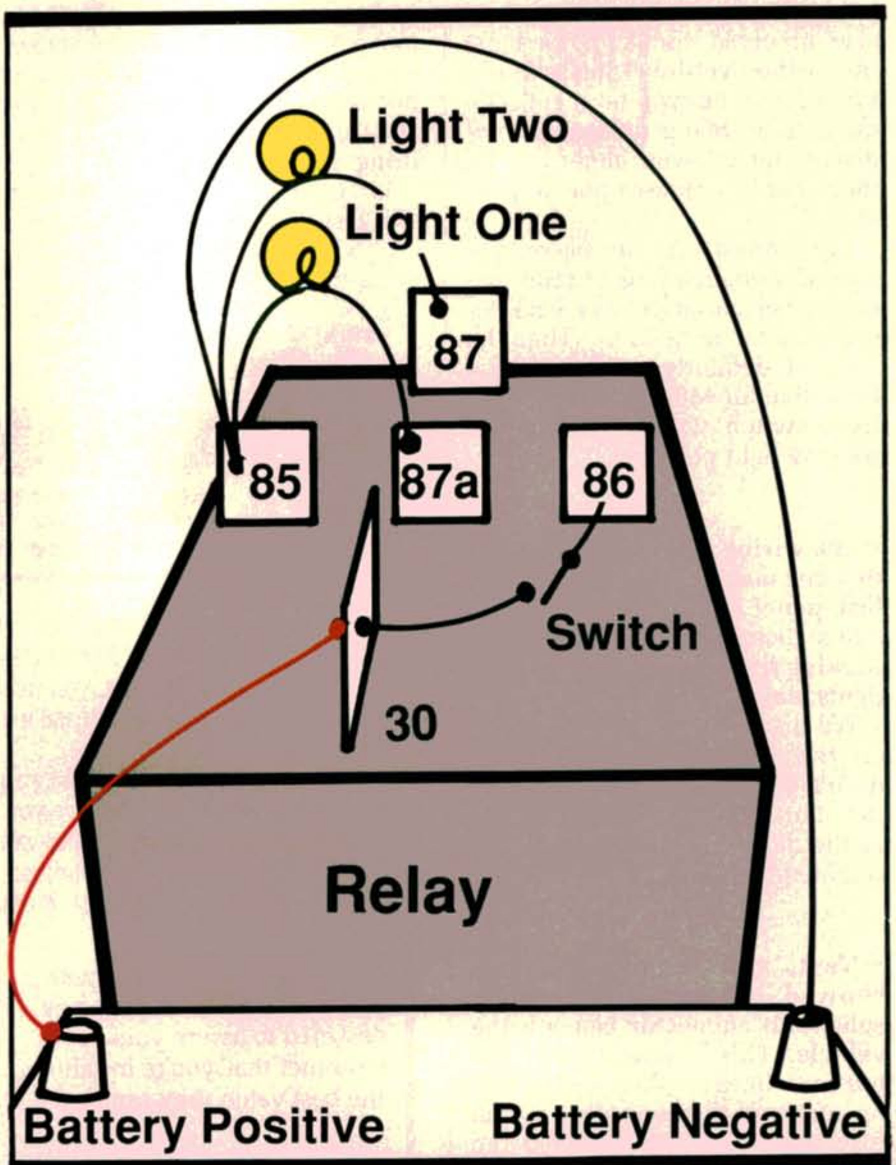
Then he drew a diagram on the back of a paper bag, handed it to me and said, "Make this. Don't bother me again until it works."

By the time the relay tester was done, I knew how to check the circuit and the relay. I understood why the relay worked as it did, and fixed the car. Besides, going back to my mentor was out of the question.

We've included a diagram of our rapid relay checker. It's a good exercise for the young techs in your shop, and it helps them better understand how inputs and outputs relate.

These Bosch-style relays are common in many cars. We'll concentrate on only two styles. The first is the common four terminal relay you've seen in so many circuits. The second is a five terminal relay which alternately toggles between two output terminals as it switches. There are of course many other relay types, but these are common, and certainly representative.

Our relays each have two switching terminals, one power and one ground, which activate an electromagnetic coil. The coil becomes a magnet and pulls down on a contact bar completing the feed circuit to the electrical consumer. This feed circuit can connect the consumer to power or ground, depending on how the circuit is wired.



Our diagram shows how to wire your relay socket for both four and five terminal relays. The five terminal relay is different from the four terminal in that it isn't a simple ON/OFF circuit like the four terminal. Instead, as the relay coil goes on or off in the five terminal relay, a switch contact toggles between terminals 87 and 87a. That means that there is continuity between 30 and 87a with the relay coil off. There is continuity between 30 and 87 with the relay coil energized.

On the four terminal relay, there is an open circuit between 30 and 87 until the relay coil energizes closing the 30/87 circuit.

Occasionally you'll see a five terminal relay in a socket with no connection for the 87a terminal. In this case, the five terminal relay is acting like a four terminal relay. Instead of disconnecting the 87 and 30 terminals when it's off, it switches to 87a which isn't connected to anything at all.

Even though we've used 86 as the hot leg of the relay coil, and 85 as ground, it's possible that in special circuits, the 85 will be hot and the 86 terminal ground.

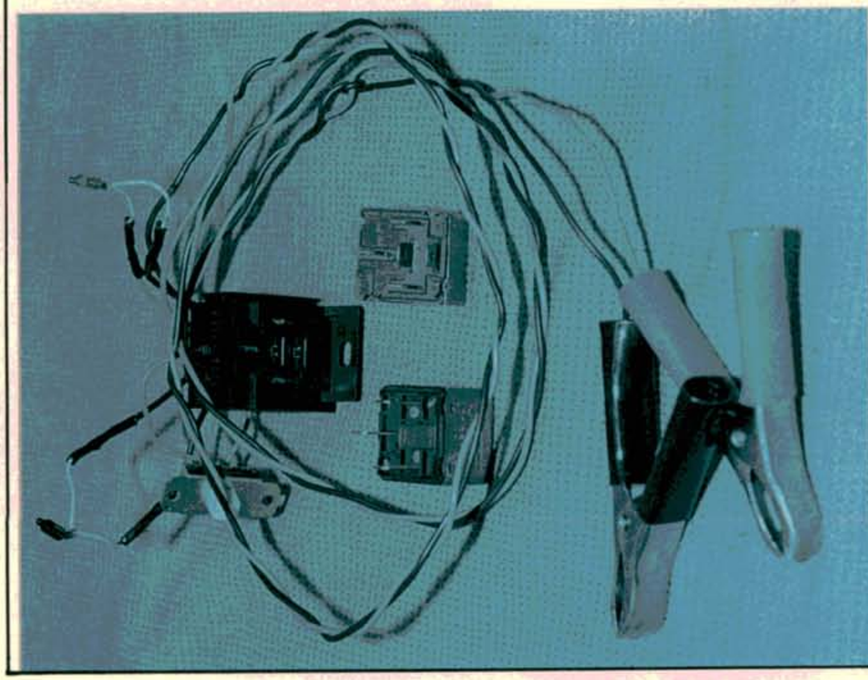
A similar thing can happen in the 30/87/87a circuit. If the 30 terminal is connected to a ground instead of a hot wire, the relay acts as a switch to ground. That's why the wiring diagram becomes so important.

How To Use The Tester

The tester is simple to use.

To Test a Five Terminal relay:
- Plug the relay to be tested into the tester socket.
- Connect the main tester leads to the battery terminals. Light number One should be on. Light number Two should be off.
- Press the momentary switch button. Light number One should go out. Light number Two should come on.

To Test a Four Terminal Relay:
- Plug the relay to be tested into the tester socket.
- Connect the main tester leads to the battery terminals. (Light number One is not used for this test.)
- Press the momentary switch button. Light number Two should come on.



Troubleshooting the Relay Circuit

Let's say that we have a dead air conditioner. There's pressure in the system, but each time we try to turn on the A/C, nothing happens. Just to be sure, we jumper the pressure cutoff switch in case it's bad. Still no resounding "clack" from the compressor clutch.

The fuse marked A/C is good, and a fuse checker shows the circuit is hot with the key on. We do hear a relay under the hood go click when we hit the dashboard A/C switch. The wiring diagram tells us that the air conditioning clutch receives its power through this relay. We remove the relay and use our checker to verify that it's not only clicking, but switching as well. It is.

We now know two things:

1) The relay works.

2) The circuit (both power and ground) which activates the relay coil is also good (terminal 86 is hot, and terminal 85 is hooked to ground.)

Terminal 87 should transmit 30 terminal power to the clutch when the relay switches, but it doesn't. We jumpered between 86 and 87 and the compressor clutch clacked loudly. Now we also know that the circuit from the relay socket to the compressor clutch and the clutch itself are good. As we said, the 30 terminal should provide power to 87 when the relay is turned on. We already know that circuits for terminals 85, 86, and 87 are good.

By process of elimination, the circuit between the fuse and the 30 terminal in the relay socket is open.

Now we can grab our DVOM and find the open. But the most important part of this entire exercise, is that we have eliminated the good circuits very quickly. Plugging the relay into the checker, jumpering the 86 to 30 terminal, and checking power at the fuse block have taken only a few minutes.

We've isolated the problem circuit, and can concentrate our efforts in that area.

Is This Too Simple?

The electrically competent among you may suggest that our tongue in cheek approach is all overly simplistic. But that's because you've already been thinking this way for years. You already realize that even complicated circuits end up as simple ones. You just assume that that's the case and take the thought process for granted.

There are certainly other ways to check these circuits with normal test equipment—assuming you know what you're looking for. But we wanted to use our wits and an understanding of the overall circuit to define and locate the problem.

This is an especially important lesson for your younger techs to learn. They often get blown away by the complexity of the main harness and need your help in breaking things down into chewable pieces.

Some of the Dyno Dons will never learn.

—By Ralph Birnbaum